Speech Production in Arabic Speaking Children with Operated Cleft Palate

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Doctor of Philosophy

By

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Abstract

This study explores the phonetic and phonological features of speech production associated with cleft palate in Saudi Arabian Arabic-speaking children. It examines data collected using an Arabic version of the GOS.SP.ASS (Sell *et al*. 1999) developed specifically for this study, to provide an account of the ways in which a history of cleft lip and palate may affect the development of speech in Arabic, and to consider the implications of these findings for our understanding of universal versus language-specific features of speech associated with cleft.

The study used speech data taken from 21 Arabic-speaking children aged from four to seven years old, and a control group of five normally developing children aged between four and five, from Riyadh, the capital of Saudi Arabia. Audio and video recordings were made of the participants' speech production in a variety of contexts, including single word production and connected speech production.

The data were transcribed using narrow phonetic transcription, and the transcriptions formed the basis for completion of Saudi Arabian GOS.SP.ASS forms for each individual participant. Phonological analysis was carried out on the data from each participant. From these preliminary analyses, descriptions of atypical speech production features were made, and categorised into those associated with the cleft palate, and those which indicated non-cleft developmental difficulties. Furthermore, descriptive analysis was carried out to determine the most and least accurate segments and to explain the relationship between accurately produced segments and the following variables: chronological age, age at repair and type of cleft palate. Individual case studies were conducted to illustrate and exemplify individual differences in the speech of four of the children with cleft palate who have contrasting speech output patterns. These case studies contribute to an exploration of inter- and intra-speaker variability in speech production associated with cleft palate.

The results of this study indicate that the speech characteristics of Saudi children with cleft palate are not entirely consistent with previous cross-linguistic studies of cleft palate speech: a series of different compensatory strategies and unusual speech production features emerged in the data which appear to reflect the phonetic and phonological properties of Arabic. Theoretical and clinical implications for assessment and intervention for speech difficulties related to cleft palate are discussed.

Dedication

This thesis is dedicated to

the soul of my father, the first person to teach me

I wish he was here to see his dream come true

and to my beloved mother

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All prayers and gratitude to God without whose help this work would not been accomplished.

I am extremely thankful to my supervisors, Professor Sara Howard and Professor Bill Wells who have helped me through the PhD journey. Their endless wisdom, advice and support have helped me to become the person who I am today. I am deeply honoured and feel privileged to have had them as my supervisors.

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Author's Declaration

I hereby acknowledge that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted to any academic institution for degree purposes.

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Chapter 1 **Phonetics and Phonology of Arabic**

1.1 General Background

Arabic is one of the most widely spoken living Semitic languages. According to Procházka (2006; as cited in Al Sayah *et al.*, 2013), the latest estimates suggest that about 240 million people use Arabic as a first language which makes it the fifth most commonly spoken language worldwide (https://www.ethnologue.com/), with 27 countries from the Maghreb (North Africa) to the Middle East using it as their first language (Figure 1-1 gives the geographical distribution of the Arabic language) (Rosenhouse and Goral, 2004). Non-Arabic speakers also use it for religious purposes, as in Pakistan, India and Indonesia (McLeod, 2007).

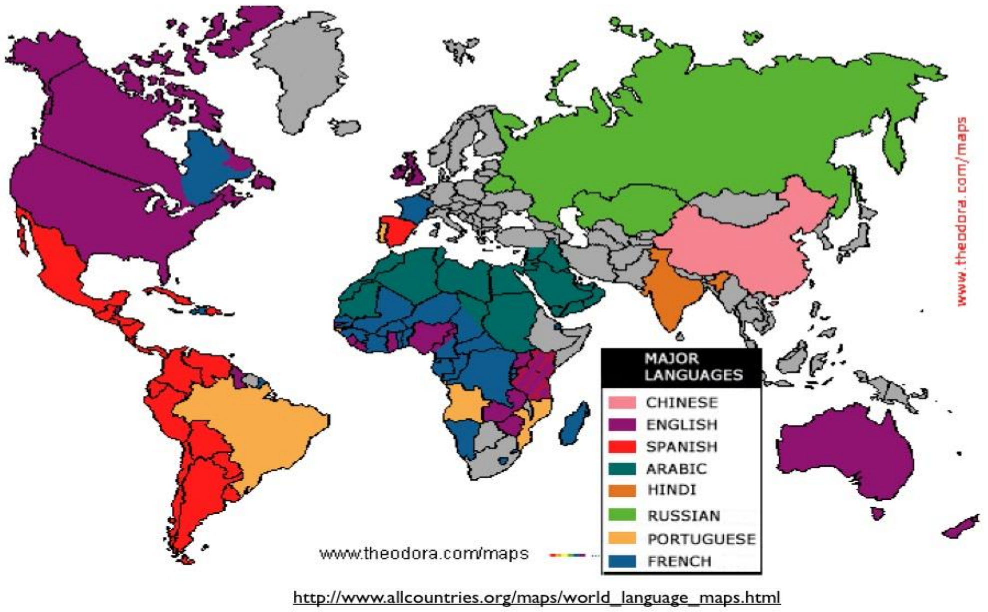

FIGURE 1-1LIST OF COUNTRIES WHERE ARABIC IS AN OFFICIAL LANGUAGE (WWW.THEODORA.COMO/MAPS/)

In some geographical regions, Arabic dialects contain a significant number of vocabulary items imported from other languages (e.g. Berber, French and English) and the sound systems reflect similar cross-linguistic influences (e.g. the French influence on Moroccan Arabic).

This chapter includes a brief overview of the Arabic language to provide a context within which to understand the language and its structure which is important, because Arabic is the language of the participants in this study.

1.2 Diglossia in Arabic

The term "Diglossia" in Arabic has been well established in the literature (Freeman, 1996; Trudgill, 2009; Jabbari, 2013) and refers to a linguistic situation in which two forms are used for the same language. In this context, Ferguson (1959; 2000; as cited in Li, 2003) suggested that two forms are present in Arabic and are used differently in different social contexts. These are Literary Arabic (LA) and Colloquial Arabic (CA). Literary Arabic, (also known as Modern Standard Arabic (MSA) is the formal form of Arabic that is largely confined to use by educated speakers in formal contexts such as conventions and lectures. It is not spoken by anyone in the Arab countries as their native language. However, literature in Arabic is often written in this form; therefore some consider it as the Eloquent Language (Rosenhouse and Goral, 2004). According to Abu-Al-Makarem (2005, as cited in Abu-Al-Makarem, 2007) it is suggested that this form is based on the Classical or Qur'anic Arabic.

On the other hand, Colloquial Arabic is the unofficial form of the language, as used in informal situations and everyday conversations. It differs from the former in all domains of language structure; that is, phonology, morphology, syntax, semantics, pragmatics and vocabulary (Rosenhouse and Goral, 2004). Furthermore, Colloquial Arabic includes different dialects that can be unintelligible to different people within the Arabic-speaking community. In general, native speakers can make considerable use of both forms (i.e. Literary Arabic and Colloquial Arabic); with one or the other used depending on a given situation. Comparisons between the MSA and the Egyptian CA and the Iraqi CA were made in two different recently conducted studies (Jabbari, 2012, 2013). As shown from the two studies, there are radical differences between the two forms in terms of phonology, semantic, lexicon and morpho-syntax.

Debate continues as to whether Diglossia is best described as a form of bilingualism with some researchers supporting this position (e.g. Rosenhouse and Goral, 2004), while others, like Fishman (1967), considered Diglossia as a sociolinguistic form that differs from bilingualism; however, the aforementioned linguists (Rosenhouse ad Goral,2004) have not adopted such a view. More recently, however, it has been argued, though, that Arabic is not diglossic but rather a triglossic or even a quadriglossic language (Al-Awaji and Al-Shahwan, 2010). This is compatible with the suggestions in the recent literature on the triglossic nature of Arabic where it is divided into three distinct forms: Classical Arabic (CA), Modern Standard Arabic (MSA), and Colloquial Arabic (spoken) (Ameyrah *et al*., 1999; Saiegh-Haddad, 2004). The argument for quadriglossia (which has been suggested by Al-Awaji and Al-Shahwan, 2010) is that, Classical Arabic should not, as mentioned above, be considered to be the same as the language of the Qur'an but instead this form of Arabic needs to be viewed as a separate form. It is 'Kalamu Allah' (God's words) that were revealed to the prophet Mohammed both in words and meaning, while Classical Arabic is written by humankind. Using this categorisation, Qur'an and Classical Arabic are two forms of the language along with modern standard Arabic (taught in educational settings) as well as Colloquial Arabic (spoken form) (see Table 1-1 below).

Dialectal variations exist in each region, from country to country and within the same country. When the distance increases between any two regions, the dialectal differences will increase accordingly. For example, in Saudi Arabia there are five different main dialects spoken depending on the region (see Figure 1-2); these are the central dialect (Najdi) that is mostly spoken in Riyadh and other cities in the central region of Saudi Arabia, the western dialect (Hijazi) spoken in Makkah Almukarramah, Madinah and other regions in the western area, the northern dialect, the eastern dialect (Gulf) and the southern dialect. Although most people within a particular region speak the same dialect (e.g. Najdi dialect) there are still differences in terms of accents due to social differences.

Table 1-1 Classification of Spoken Arabic Language

Proposed classification of the spoken Arabic Language (Al-Awaji *et al.* , 2010)[1]			
Qur'an	**Classical Arabic**	**Modern Standard Arabic**	**Dialects**
-Allah's holy scriptures. -Unified form that has not been changed for more than 1400 years. -Used five times a day for prayers and is read.	-Language of poetry and literature from pre-Islamic times.	-Language of media and.education -Alfusha -This form can be affected by the dialect spoken	***-White dialect*** (general dialect) ***-Colloquial*** Urban based on regions. -Bedouin tribes (Otaiba Onaizah, etc). -Religious (e.g. Shi'i and Sunni in Bahrain).

The dialectal variation among Saudi regions is clearly noticed in the use of different words for the same meaning (lexical differences) - for instance, "window" can be expressed differently as /ʃub.baːk/, /dɪriːʃah/ or /tˤaːgah/). Variations also occur in grammar, whereas accent differences manifest in different ways of producing consonant phonemes and/or vowels (which will be described later in this chapter). Thus, it is essential for speech therapists to have a clear understanding of accent variations in order to make a proper decision on whether the speech produced by the speaker is considered to be appropriate for the regional dialect or not.

In addition to the above dialects, there is another form of dialect which is known as White dialect (*Al-Lahjaa Albayda*). White dialect is a well-known term used by Saudi Arabic speakers in particular as well as speakers in other Arabic countries to a lesser extent, and it is considered as a general dialect, which is mostly used by people when dealing with people from other regions for the purposes of being mutually intelligible. White dialect could be defined as 'a conscious higher form of dialectal Arabic that is characterised by detaching itself as much as possible from the distinctive features of the person's dialect, specifically, suffixes and prefixes, and other features depending on the dialect are absent' (Al-Awaji and Al Shahwan, 2012).

[1]Nisreen Al-Awaji, Majid Al-Shahwan and Dalia Abdulqader's presentation in the Arabic phonetic group meeting was conducted in 2010 at the University of Sheffield

FIGURE 1-2 SAUDI ARABIAN'S MAIN DIALECTS

(SOURCE: MGHAMDI.COM)

1.3 The Phonetic and Phonological System of Arabic

1.3.1 Consonantal system of Arabic

With his book *Kitab Al-ain*, Al Khalil was the first author who studied Arabic phonetics in the seventh century. He arranged the Arabic alphabet into 28 letters from the lips to the larynx and analysed them according to their distinctive features. Thus, according to Al Khalil's classification, Modern Standard Arabic has 28 consonant phonemes, eight stops, 13 fricatives, one affricate, two nasals, one glide, one approximant, one trill and one lateral which are classified into place and manner of articulation and also according to voiced and voiceless consonants. From the 28 consonants, two consonants, /w/, /j/, are considered to be semivowels rather than full consonants.

Arabic is described as *lʊʁatʊ ‘dˤaːd* (that is “Language of /dˤ/”) by many Arab grammarians due to the presence of a single extra feature (/dˤ/) which is not present in any other language worldwide. Thus, the most prominent acoustic feature in Arabic is often said to be its guttural quality. Gutturals in Arabic are those produced in the pharyngeal and uvular regions (McCarthy, 1989). The phonological system of guttarals includes five consonantal phonemes produced in the velar and post-velar region of the vocal tract. These include a voiceless uvular plosive /q/, voiceless and voiced uvular fricatives /χ, ʁ/ and voiceless and voiced pharyngeal fricatives /ħ, ʕ/. Furthermore, there are four emphatics which have been notated in the research literature by different symbols and diacritics; a *tilde* running through a main symbol /~~s~~, ~~d~~, ~~t~~ ,~~ð~~/, a dot under the main symbol /ṣˤ, ḍˤ, ṭˤ, ð̣ˤ/, an *underline* used with the main symbol /s̱, ḏ, ṯ, ð̱/, or using the *IPA* conventions, as /sˤ , dˤ, tˤ , ðˤ/. In this study IPA notation has been used. The four emphatics form an important part of the Arabic consonantal system where they contrast with the four obstruents /s, d, t and ð/. The emphatics differ from the latter in that the primary anterior articulation accompanied by a secondary articulation that involves retraction of the tongue body toward the pharynx. Sometimes /q/ is also considered to be an emphatic sound due to its posterior place of articulation (e.g. Al-Ani, 1970).

In Saudi Arabic, the phonetic features in a given accent/dialect differ from those in MSA. In addition, they differ from one dialect to another. The sound system tends to be restructured. Thus, the consonant inventory is reduced, compared to MSA, but the vowel inventory is increased (this is described in more detail later in Section 1.3.2). As in MSA, Saudi Arabic has a number of emphatics, uvulars, pharyngeals and glottals along with additional consonants (e.g./zˤ,g/) which might occur consistently or inconsistently depending on the dialect; such realisations, which might occur on the level of single speech sounds or of a whole word, are considered to be socio-phonetically acceptable. For example, in Saudi

Arabic, the sound /q/ is usually realised as [g] in almost all of the colloquial forms of Saudi Arabian dialects (See Table 1-2).

Replacements have also been observed not only in Saudi Arabic but in other Arabic-speaking countries such as the Gulf countries, Jordan, Syria and Egypt (See Table 1-3). For example, the word /qird/ (monkey) is pronounced as /gird/ in Saudi Arabic. In comparison, dialects such as Cairene, Syrian, Palestinian and modern regional dialects of Jordan replace the uvular sound /q/ with a glottal stop /ʔ/.

Table 1-2IPA-type chart of the consonants of Saudi Arabic

	Bilabial	**Labio-dental**	**Dental**	**Alveolar**	**Post-alveolar**	**Palatal**	**Velar**	**Uvular**	**Pharyn-geal**	**Glottal**
Plosive	b			t d			k g	q		ʔ
				tˤ dˤ						
Nasal	m			n						
Fricative		f	θ ð	s z	ʃ ʒ		x ɣ	χ ʁ	ħ ʕ	h
			ðˤ	sˤ zˤ						
Affricate					dʒ					
Trill				r						
Tap or flap				ɾ						
Glide	w									
Approximant						j				
Lateral*				l			L			

*Target consonants in red represent additional consonants to those in MSA

Table 1-3 Replacements of consonants as dialectal variants (Ingham, 1971, 1994), (Amayreh and Dyson, 2000)

Target Segment	Replacement
/q/	[g]
/ʁ/	[q]
/dˤ/	[ðˤ]
/r/	[ɾ]
/ðˤ/	[dˤ],[zˤ]
/ð/	[z],[d]
/θ/	[s],[t]

1.3.2 Arabic vowels

The MSA vowel system consists of six vowels, two diphthongs /aj/ and /aw/ and following the suggestion of Omar (1991), two approximants /w/, /j/. The MSA vowel system consists of six vowels, two diphthongs /aj/ and /aw/ and following the suggestion of Omar (1991), two approximants /w/, /j/. The monophthong vowels are categorised phonologically into three short vowels and three long vowels of similar quality but different length /i, i:, a, a:, u, u:/. In dialects that use emphatic consonants (i.e. therefore including Saudi dialects), some vowels differ considerably depending on phonetic context, particularly /a/ and /a:/ (Phonetically [æ] and [a:]) which become [ɑ] and [ɑː] (Fareh *et al*., 2000).

Some dialects, however, may involve more than six vowels, as indicated in Ingham's (1971) study on the Meccan dialect (Hejazi), where he argued that the vowels /o, ʌ, ə/ have been observed in Meccan dialect speakers. Egyptian Arabic is another example of dialects which have more than six vowels including [i], [iː], [u], [uː], [a], [aː], [e], [eː], [o], [oː] (Fathi, 2013). These vowels could be considered to be different realisations of the same vowel phoneme rather than additional vowel phonemes present in Arabic dialects (i.e. Jordanian and Lebanese Arabic studies conducted by Dyson and Amayreh, 2007, and Khattab, 2007). The former vowels /o:, ə, ʌ, o/

may have been observed as a different realisation of phonemes in other Saudi dialects along with additional vowels such as /ɛ ,ɛː , e/.

1.4 Word and Syllable Structure

Al-Ani (1970), Watson (2002) and Holes (2004) all use the concept of light and heavy syllables to suggest that MSA has six syllable structures. A light syllable can be defined as having a short vowel (CV); in contrast a heavy syllable have a long vowel (CVV or CV:) or diphthong. According to this system, the syllable structures are categorised as follows:

- *Two open forms:*
    1. CV (light syllable) as in the word 'and' in Saudi Arabic and in MSA , /wa/
    2. CV: (heavy syllable) as in the word 'mine' in MSA, /liː/

- *Four closed forms:*
    1. CVC (heavy syllable) as in the word 'true' in Saudi Arabic, / sˤɑħ/
    2. CV:C (super heavy syllable) as in the word 'where' in Saudi Arabic, /fɛːn /
    3. CVCC (super heavy syllable) as in the word 'individual' in Saudi Arabic , /fard/
    4. CV:CC (super heavy syllable) as in the word 'joyful' in MSA, /saːrr/

The CV:CC syllable structure does not occur in dialects, only in MSA. Furthermore, it is restricted only to geminates in word-final position (Abu-Mansour, 1992; as cited in Broselow *et al.*, 1992).

There are some phonotactic restrictions when combining sounds within syllables. Each syllable must have an onset, and as a rule, any given vowel cannot act as an antecedent to consonants in the initial position of the word. Al-Ani (1970, as cited in Hassan and Heselwood, 2011) investigated this issue with the use of spectrographic analysis. For example, a glottal stop /ʔ/ must be inserted prior to word initial vowels in an Arabic word. Furthermore, there are no clusters in the initial position of words in MSA as a vowel is inserted automatically between two consonants which come into contact in word-initial position (e.g. /turaːb/'sand'). In MSA, clusters are only allowed to occur in word-final position (e.g. /mɪlħ/ 'Salt') but they can also occur in word-initial position in various dialects (including Saudi Arabian).

1.5 Word Stress

In MSA, Halpern (2009) presents five stress patterns which fall into the following:

- Stress always applies in the final syllable if that syllable is super-heavy, (CV:C or CVCC) , e.g.:

  /dʒaˈdiːd/ in MSA 'new' →CV/CV: C

- In monosyllabic words , stress applies on the final syllable ,e.g.:

  /bi.kam/ 'how much' → CV/CVC

- In disyllabic words, stress applies on the penultimate syllable, e.g.:

  /ˈ hi.ja/ 'her' → CV/CV

  /ˈka:tib/ 'writer' →CV:/CVC

- In polysyllabic words, stress applies on the **penultimate** syllable if that syllable is **heavy** (CVV or CVC), e.g.

/mu.ˈfiː.dun/ ‘beneficial’ → CV/CV:/CVC

- In polysyllabic words, stress applies on the **antepenultimate** syllable (third syllable from the last) if the penultimate is **light** (CV), e.g.:

/ˈmak.ta.ba/ ‘library’ → CVC/CV/CV

Several references describe stress rules in different Arabic dialects such as Cairene, San’ani and Levantine (Holes, 2004, Watson, 2007, 2011) although for the Saudi Arabic dialect; nothing has been published specifically on this matter.

1.6 Summary

This chapter has presented an outline of the phonetics and phonology of Arabic covering diglossia in Arabic and its basic forms. The phonetic and phonological systems of Arabic including consonantal and vowel systems were described. The latter section provides a description of the different phonetic and phonological systems in both MSA and Saudi Arabic. Word and syllable structure has also been considered. As the aim of the current study is to describe speech production features in young Arabic speakers with cleft palate, it is essential to provide an overview of the phonetic and phonological development of Arabic by young children and to compare these findings with those of studies conducted in English. The next chapter is dedicated to this.

Chapter 2 Main patterns of phonological development in English and Arabic

2.1 Introduction

Throughout the literature, there is a large bulk of studies from different languages focusing on speech development for typically developing children, although most of these studies are focused on English. The current chapter reviews speech development in English and Arabic by typically developing children. The purpose of this review is to differentiate between speech processes related to normal phonological development and atypical speech processes related to cleft palate. This is addressed by reviewing phonological processes frameworks and speech development in both English and Arabic. The last section gives an overview of phonetic acquisition and phonological processes for both English and Arabic.

2.2 Phonology

The version of the GOS.SP.ASS developed for this study was aimed at speakers of the Saudi Arabian dialect. However, the review of Arabic given here relates to MSA, as the standard reference form, because to date there are no reliable accounts of the phonetic and phonological structure of the Saudi Arabian dialect. Where reference is made to Saudi variants in this study, they have been suggested by native informants and by the author, who is a native speaker of Saudi Arabian Arabic. The lack of published studies on the Saudi Arabian dialect suggests that this is a valuable area for speech research in the future.

According to Gordon-Brennan and Weiss (2007), phonology represents one of the components of language systems, together with semantics, syntax and morphology. Stoel-Gammon and Dunn (1985) suggest that phonology refers "the organisation and classification of speech sounds that occur as contrastive units... and ...it is used as a general term to cover all aspects of the study of speech sounds including speech perception and production as well as cognitive and motor aspects of speech ...” (Stoel-Gammon & Dunn, 1985, p.3-4). That is, the latter authors believe that the phonetic inability to produce the required movements of a particular sound may be related to many factors, which involve, for example, the child’s perception or production. Thus, a child with phonological disorder might have a problem with auditory perception and thus have difficulty, for example, distinguishing minimally distinct sound sequences. Concerning the motor aspect of speech, Stoel-Gammon and Dunn (1985) pointed out that children with phonological disorder may have some kind of motoric problem or immaturity which restrict the child’s ability to speak normally (e.g. Developmental Apraxia of Speech (DAS)).

Ingram (1976) and Grunwell (1975, 1981) described systematic speech behaviour encountered by children with atypical speech production, with reference to the concept of phonological processes. These have subsequently been widely used as a framework for speech assessment and intervention. There are several other phonological theories and frameworks which could be used in clinical analysis; however despite some limitations concerning its clinical application (Miccio and Scarpino, 2008), the phonological processes approach is still considered to be the most commonly used framework (Howard, 2011), and this applies to speech development and speech disorder including cleft palate.

In this study, a phonological processes framework is employed in order to describe speech behaviours other than cleft palate speech errors, which are employed by children with cleft palate, to simplify the sound system and word structure. It is also used to describe speech behaviour for the control group.

A phonological process approach has been chosen specifically because:

1. It offers the possibility for categorising children's speech output within a developmental framework. On this matter, Grunwell (1982) drew a distinction between phonological errors that occur as part of normal development (typical for the child's chronological age) and errors that are considered to indicate a phonological delay or disability. She classified the latter into three subcategories:

    - Persisting normal processes (similar to Ingram's classification of phonological delay): in this category, the child tends to use phonological processes which largely match those of his/her peers at a younger age.
    - Chronological mismatch: where phonological delays exists along with some additional advanced phonological development.
    - Idiosyncratic processes: the child's use of atypical processes which have not been identified in the literature as part of normal phonological development (Ingram, 1976 referred to this as phonological deviance).

2. As already mentioned, phonological processes classify simplified productions used by children for the adult targets and thus provide a framework to describe both typical and atypical phonological processes (Grunwell, 1985; Stoel-Gammon and Dunn, 1985). Specifically, it is useful in terms of providing comparisons between errors related to typical speech development and abnormal patterns related to other speech development disorder (Grunwell, 1982; Miccio and Scarpino, 2008).

3. Chapman (1993) recommends that the assessment of speech sound production for children with cleft palate should distinguish between typical and atypical phonological processes. Chapman's recommendation is followed in the current study. A phonological processes framework is used to describe the typical developmental and delayed phonological

simplifications encountered in both the cleft palate group and the control group. In the case of specific speech characteristics related to cleft palate, the GOS.SP.ASS categories of cleft speech characteristics are used.

2.3 Phonological Processes Framework

This section is divided into three sub-sections:

- Common phonological processes occurring in both English and Arabic
- Phonological processes occurring in English but not reported for Arabic
- Phonological processes occurring in Arabic but not reported for English

2.3.1 Phonological processes in both English and Arabic:

In this section, the classification of phonological processes is based on Grunwell (1982) and Miccio and Scarpino (2008). English and Arabic examples are given for each process. It is notable that all processes described for English, by Grunwell, were also found in Arabic.

2.3.1.1 Word and syllable level processes: where the shape of the word or a syllable is affected. These are categorised into:

- Unstressed syllable deletion

Examples	
English	‘telephone’ /ˈtɛlɪfəʊn/→ [tɛfəʊn]
Arabic	‘Orange’ /bur.tuˈqaːl/→[tuqːl],in MSA and Saudi dialect

- Final consonant deletion

Examples	
English	‘cup’ /kʌp/→ [kʌ]
Arabic	‘house’ /bɛːt/→[bɛː],in Saudi dialect

- Cluster reduction

Examples	
English	‘straight’ /streɪt/→ [teɪt]
Arabic	‘money’ /fluːs /→ [fuːs],in Saudi dialect (but not MSA)

2.3.1.2 Assimilation processes: Assimilation is “the process in which a sound becomes similar to or is influenced by another sound in the word” (Ingram, 1989: 34). Therefore, in the following examples, a consonant is changed to become more like another consonant in the same word.

Examples	
English	‘yellow’ /jɛləʊ/→[lɛləʊ]
Arabic	‘carrot’ /dʒazar/→[dʒadʒar] , in MSA and Saudi dialect

2.3.1.3 Substitution processes: occur by substituting place of articulation, using a simpler manner of articulation or a voicing change.
It can be divided into:

- Stopping: replacing fricatives or affricates by stops

Examples	
English	‘Shake’ /ʃeɪk/→[teɪk]
Arabic	‘Tooth’ / sin/ →[tin], in MSA and Saudi dialect

- De-affrication: replacement of affricates by fricatives or stops (Rupela *et al*., 2010)

Examples	
English	‘Chair’ /tʃɛːr/→[ʃɛːr] ‘Job’ /dʒɒb/→ [dɒb]
Arabic	‘Carrot’ /dʒazar/→ [dazar]in MSA and Saudi dialect ‘mobile’ /dʒaw.ˈwaːl/→[zaw.ˈwaːl] in Saudi Arabic

- Velar fronting: use alveolar placement [t, d] for velar plosives /k, ɡ/.

Examples	
English	‘cup’ /kʌp/ →[tʌp]
Arabic	‘knife’/sɪk.ˈkiːnah/→[sɪt.ˈtiːnah], in MSA and Saudi dialect

- Vocalisation: using a vowel instead of a consonant for liquids.

Examples	
English	‘simple’ /sɪmpəl/→ [sɪmpʊ]
Arabic	‘break’ /ʔik.ˈsir/→[ʔik.ˈsɔ], in Saudi dialect.

- Context-sensitive voicing/devoicing: voiced obstruents can be produced as their voiceless cognates, which occurs mostly in pre-vocalic position. Voiceless obstruents can also be produced in place of their voiced cognates, most often in word-final position).

Examples	
English	‘egg’ /ɛg/→ [ɛk]
Arabic	‘door’ /ˈbaːb/→[ˈbaːp], in Saudi dialect.

2.3.1.4 Backing: backing refers to posterior placement of anterior consonants and is generally not considered to be part of typical development.

Examples	
English	'top' /tɒp/→[kɒp]
Arabic	'dates' /tamur/→[ka'mur], in Saudi dialect

2.3.2 Phonological processes occurring in English but not reported for Arabic

- Gliding : replacing liquids with glides.

Examples	
English	'lamb' /lam/→ [jam]
Arabic	This process has not been reported in Arabic

2.3.3 Phonological processes occurring in Arabic but not reported for English

The Arabic sound system contains a number of items which do not occur in English, but which are affected by phonological processes:

- /r/ realisations: /r/ in Arabic is an alveolar trill, which may be lateralised /r/→[l] or substituted by a glide /r/ → [w]. Furthermore, it might be deleted or assimilated (Ammar and Morsi, 2006).

e.g. 'Monkey' /qɪrd/→[gɪld], in MSA and Saudi dialect (lateralisation of /r/)

'Cold' /ˈbard/→[ˈbawd], in MSA and Saudi dialect (gliding of /r/)

- De-pharyngealisation (i.e. de-emphasis): this process affects the emphatics and involves the loss of the secondary articulation (e.g./$d^{ʕ}$/→[d]) which has been reported frequently in Arabic studies (e.g. Dyson and Amayreh, 2000; Ayyad, 2011).

e.g. ‘box’ /$s^{ʕ}$an.duːq/→[san.duːq] in MSA and Saudi dialect

- Non-cleft pharyngeal backing: In this process [ʕ, ħ] are used as replacements for voiceless and voiced uvulars.

e.g. ‘sheep’ /χaruːf/→ [ħaruːf]

2.4 English Speech Development

The following section reviews the literature on speech development starting with English and then moving on to describe Arabic speech development. Considering the speech development for typically developing children is important so that normal speech process presented in the cleft group could be differentiated from the processes related to cleft palate.

The phases of English phonological acquisition summarised below are based on the speech development framework described by Edwards and Shriberg (1983), Stoel-Gammon and Dunn (1985), and Gordon-Brannan and Weiss (2007).

2.4.1 Pre-linguistic development (0; 0 -1; 0)

Prior to the onset of meaningful speech and specifically in the first month of life, all infants, across all languages, produce an enormous mixture of sounds which involve cries, coughs, burps, or wheezes. Such utterances do not need to be acquired in a specific order. At the age of two to three months vocalisations of vowel-like sounds occur, and by six to seven months the majority of infants produce nonlexical CV syllables (also known as canonical babbling). As cited from MacNeilage (2013: p.301), babbling is "… *one or more instances of a rhythmic alternation of a closed and open* *mouth, produced by a mandibular elevation/depression cycle, accompanied by vocal fold vibration, and linguistically meaningless, though giving the perceptual impression of a consonant-vowel (CV) sequence".*

With the start of CV babbling, most consonants are first produced in the back of the mouth and then moved to the front, (i.e. lips or front of the tongue). In the second half of the first year, the consonantal inventory extends substantially. Robb and Bleile (1994), for example, suggested that during this stage infants produce all sounds present in all languages of the world. Locke (1983) argued, however, that the consonant inventory is, in fact, limited to nasals, stops and glides. He also added - as also commented on by other authors (Kent and Bauer 1985; Stoel-Gammon, 1985; Vihman *et al*., 1985; Oller, 2000; Nathani and Oller, 2001; Vihman and Kunnari, 2006) - that there is a discernible similarity between the phonetic inventory of babbling and a child's early phonology.

The pre-linguistic period is an essential phase in the child's transition from the use of non-sense syllables to meaningful syllables. For example, at the age of seven months, the infant who repetitively uses babbled syllables (e.g. [ma]) becomes conscious about the tactile and kinesthetic sensations accompanying the syllable and also understands the acoustic output that is related with the production "feedback loop". The connection of these articulatory-auditory systems is important for the child's speech production (Stoel Gammon, 1998). Thus, at this stage, the child makes a transition from the babble [ma] to the real word [ma:ma:] and reaches the stage of meaningful speech.

2.4.2 From babble to early words (1;0 - 1;6)

Generally, the first words are usually produced by the first birthday. Words start to appear and babbling continues to coexist with these words for several months. Stoel-Gammon (1998) reported that the same consonants and syllable types in the babble stage are used in the early words. The age of onset of meaningful speech differs from one child to another. This stage involves the period from the start of meaningful speech and growth of vocabulary repertoire up to the acquisition of 50 words (MacNeilage *et al*., 1997). It involves a limited range of consonants and vowels as well as syllables; for example, the syllable shapes used in English in the first word stage include CV, CVC and CVCV (Ferguson, 1978). In general, the consonant repertoire for a child learning English is composed of stops such as /t/, /d/, /p/, /b/, nasals such as /m/, /n/ and the glide /w/.

Studies revealed that similar inventories are generally used in other languages in terms of consonants, vowels and syllable structure. However, specific language influences will also occur where some sounds, syllable structures or stress patterns tend to occur more frequently in one language than the other. For instance, in English, the child tends to produce many CVC syllables (e.g. book) as well as disyllables with stress on the first syllable (e.g. daddy, mommy), whereas, in French the child tends to produce more nasal consonants and the tendency to use more disyllabic words with stress added in the final syllable (De Boysson-Bardies *et al*., 1992; Velleman *et al*., 2006).

2.4.3 Phonological development phase (1;6 - 5)

Beyond the first word stage, the phonemic development stage starts where an ongoing development occur from first words toward more adult-like speech (Stoel-Gammon and Dunn, 1985). At 18 months of age, the child's vocabulary size develops rapidly with an increase of syllable structures as well as the onset of two-word utterances. By the age of 24 months, the child now has the ability to produce from 250 to 350 words as well as multiword sentences (Stoel-Gammon, 2010). The sound inventory mainly involves stops such as /p/, /b/, /t/, /d/, /k/, /g/ labial and alveolar nasals /m/, /n/ and glides /w/, /j/ (Stoel-Gammon, 1985). By 36 months, the phonetic repertoire involves sounds from almost all manner and place classes of English (i.e. /p, b, t, d, k, ɡ, m, n, ŋ, f, v, s, z, h, w, l, j, tʃ/ (Dodd *et al*., 2006). By 42 months, the speech inventory increases to include further consonants such as fricatives (/ʒ/) and affricate (/dʒ/) (Dodd *et al*., 2006). In general, Coplan and Gleason (1988) suggested that by 36 months, the child's speech is 75% intelligible and by the age of four the child's speech becomes completely intelligible. In terms of vowels, Donegan (2013) noticed that by the age of three years, the percentage of accurate use of vowels was 100%.

Dodd *et al*. (2006) reported the following phonological processes which occur as a part of speech development (See Table 2-1).

Table 2-1 Phonological processes of children between the ages of (3;0-5; 11)

Phonological processes	Age group
Stopping	3;0-3;5
Weak syllable deletion	3;0-3;11
Fronting	3;0-3;11
Cluster reduction	3;0-4;11
De-affrication	3;0-4;11
Gliding	3;0 -5;11

The full phonemic inventory is finally acquired in this final stage, according to Dodd *et al*. (2003, in Mcleod, 2007, p.195). The last sounds to be acquired are /θ/, /ð/ and /ɹ/.

2.5 Arabic Speech Development

Although there is extensive literature covering English phonological development, only limited studies have been conducted on normal phonological development in some Arabic dialects. To date, there are virtually no available published studies on phonological development in Saudi Arabic children. The reasons behind the limited studies in Arabic might be due to the presence of different dialects across Arabic countries.

To this point, the available studies on speech development in Arabic involve Jordanian and Palestinian Arabic speakers (as in Amayreh and Dyson, 1998, Dyson and Amayreh, 2000 and Amayreh, 2003), Egyptian Arabic (as in Omar, 1973, Ammar and Morsi, 2006 and Saleh *et al*. ,2007), Ayyad's (2011) study on Kuwaiti speakers and Al-Buainain's *et al*. (2012) study on Qatari speakers.

2.5.1 Jordanian and Palestinian Arabic

Amayreh and Dyson (1998) conducted a normative study on 180 monolingual Jordanian children aged from 2;0 to 6;4. They examined the acquisition of the Arabic consonant inventory in Jordanian speakers and aimed to determine the percentage of children producing each consonant correctly across different word positions. They also looked at the ages at which children reach the level of customary production (i.e. at least 50% accuracy in at least two word positions), acquisition age (i.e. 75% accuracy in all word positions) as well as mastery (i.e. 90% accuracy of consonants in all word positions). Amayreh and Dyson also looked at the standard or acceptable variant productions of consonants. They divided the participants by age into nine groups, with 10 boys and 10 girls per group.

According to the authors, some findings were similar to English in the acquisition of sounds and some findings were different to English. Their study grouped Arabic phonemic acquisition into three development stages: early (2;0 to 3;10), intermediate (4;0 to 6;4) and late (after the age of 6;4), following Ingram's 1989 system. Overall, the results showed that stops were generally acquired earlier than fricatives and front consonants occur before back sounds. For emphatic consonants, it appears that their acquisition lagged behind non-emphatic consonants and the same is true for voiced consonants where they follow the acquisition of their voiceless cognates. Such findings support Jakobson's (1968) hypothesis in which he suggested that there are universal patterns across languages of the world when it comes to phonemic acquisition, including the prediction that all languages develop voiceless sounds earlier than their voiced cognates. The latter suggestion was clearly found in Amayreh and Dyson’s (1998) study.

On the other hand, the acquisition of other consonants do not fully support Jakobson’s predictions, as some back consonants, including /k/, /x/ and /h/, are acquired in the early stages of speech development , rather than the later stages as Jakobson would predict. The early acquisition of these sounds reflects the observations of more recent authors (e.g. Ingram and List, 1987, Ingram, 1989, Beckman and Edwards, 2000 and Stokes and Surendran, 2005), who have hypothesised that an explanation for these patterns is that consonants that are heard frequently (high functional load) are acquired first.

In the early period, children acquired 10 consonants (see Table 2-2), whereas most of the fricatives, affricates and /r/ were acquired in the intermediate stage. For the late period, Amayreh and Dyson (2003) suggested that most of the consonants that have not been acquired in the earlier stages are acquired in this stage, including emphatic and pharyngeal sounds.

Table 2-2 Ages of consonantal acquisition of MSA (Amayreh and Dyson, 1998; Amayreh, 2003)

Early (< 2;0 to 3;10)	**Intermediate (4;0 to 6;4)**	**Late (> 6;4)**
/b/, /t/, /d/, /k/, /f/, /h/, /m/, /n/, /l/, /w/	/χ/, /s/, /ʃ/, /ħ/, /r/, /ʁ/, /j/	/tˤ/, /dˤ/, /q/, /ʔ/, /θ/, /ð/, /ðˤ/, /z/, /sˤ/, /ʕ/, /d͡ʒ/

Amayreh’s and Dyson studies (Ameyreh and Dyson, 1998, Amayreh, 2003) are important for our understanding of the Jordanian dialect. However, they leave some ambiguity, as the authors did not provide a clear description for the criteria used to define *customary production*, *age of acquisition* and *mastery*. Additionally, the authors did not appropriately assess the terms of *standard* and *acceptable*.

In 2000, Amayreh and Dyson studied the speech inventory of 13 normally developing Arabic speaking children under the age of two (i.e. six boys and seven girls between the ages of 14 and 24 months). Spontaneous speech samples were recorded and transcribed by two examiners using narrow phonetic transcription.

Samples were examined as follows:

- Consonant inventories in different word positions (i.e. initial, medial, (syllable initial and syllable-final) and final positions).
- 'Preferred' consonants use by some of the children.
- Frequency of occurrence of consonants and their rank order.
- Frequency occurrence of vowels.

Results from this study showed that the number of consonants produced by each of the children between the ages of 14 and 24 months ranged from seven to 18, with an average of 11. The consonants that occurred include: /b/, /m/, /w/, /f/, /θ/, /d/, /t/, /n/, /s/, /z/, /l/, ʃ/, /j/, /k/, /g/, /ʔ/, /χ/, /ħ/, /h/ and /ʕ/.

In another study, Dyson and Amayreh (2000) examined phonological patterns in 50 children aged between two and 4;4 years, in five groups, each group involving 10 children, five of each gender. Speech samples were collected using a 58-word picture-naming articulation test and then transcribed[2]. The aims of this study were to determine the percentage of consonants that are differently produced from the adult targets. Furthermore, it looked at the phonological processes or patterns observed and thus it is the only study conducted by Amayreh and Dyson on the phonological processes approach.

The study found that children use a number of processes including weak syllable deletion, glottal replacement, and regressive assimilation as well as other simplification processes such as stridency deletion (i.e. deletion or

[2] Type of transcription (i.e. narrow or broad) was not specified in the study.

substitution of one of the strident sounds (i.e./s,z,f,v,ʃ,j/)), de-pharyngealisation (i.e. de-emphasis), lateralisation of /r/, syllable reduction, final consonant deletion, consonant sequence reduction (i.e. Dyson and Ameyreh's term for weak syllable deletion), fronting, post-vocalic devoicing, pre-vocalic voicing and stopping. Dyson and Amayreh suggested that some of the processes are present either as a result of the difficulty in articulation (i.e. de-emphasis, lateralisation and consonant sequence reduction) or due to the infrequent occurrence of the consonant (i.e. emphatics) in Jordanian Arabic in comparison with other varieties of Arabic, as they tend to be replaced with other consonants as dialectal variants (See Appendix 5). Arabic emphatics are, in fact, produced with the use of primary and secondary articulations. The primary articulation involves an anterior tongue stricture, whereas secondary articulation involves retraction of the tongue body into the oropharynx (Bin-Muqbil, 2006). Thus, due to the complexity of the articulatory gestures involved in the realisation of these phonemes, children in Amayreh and Dyson's study appear to apply de-emphasis by omitting the secondary articulation of emphatic sounds (/tˤ,dˤ,sˤ,ðˤ/).

It has been noticed from the study that the authors used the MSA in their speech sample to evaluate the production of preschool-age children. However, this form of Arabic is difficult for such an age group as they are still unlikely to use MSA at this stage.

Furthermore, Amayreh (2003) conducted a more recent study on 10 Arabic consonants /t, dˤ, q, ð, θ, ðˤ, z, sˤ, ʕ, dʒ/ that had not been acquired by the onset of the late period (by 6;4). Sixty Jordanian children were selected randomly and equally divided into two groups, with 15 boys and 15 girls in each group. The first group ranged in age from 6;6 to 7;4 and the second group ranged from 7;8 to 8;4. Eighty words were used to elicit the speech sample either by picture naming and/or reading. In this study, Amayreh found that the late production of the 10 consonants is related to the great tendency of children to use variable productions of the consonants depending on their local dialect, in addition to the difficulties in production of some of these consonants in their low functional load. Including these sounds is essential in the child's phonological system before school age (i.e. before the age of six). The author found that /ʕ, z, q, dˤ/were acquired by the ages of 6;6-7;4 and /tˤ/ was acquired by the ages of 7;8-8;4. Interestingly, consonants /dʒ, sˤ, ðˤ, θ, ð/ were not yet acquired even by the oldest children at the age of >8;4 but were produced differently as an acceptable variant (e.g. /dʒ/→[ʒ]). The author suggested two reasons to explain the late acquisition of these sounds: difficulty in production for some consonants, and their low functional load. It can also be suggested that the following consonants /dʒ, sˤ, ðˤ, θ, ð/ are, in fact, replaced by these consonants [ʒ, z, zˤ, s, z] respectively as the latter are acceptable variants in the Jordanian dialect and this could be an additional explanation for the late acquisition of these consonants.

2.5.2 Cairene Egyptian Arabic

Ammar and Morsi (2006) investigated the acquisition of Egyptian Arabic phonology. Their study described typical phonological development using data from 36 typically developing Egyptian children aged between three and five years old. They divided the children into two groups: The first group (aged three to four year-old) included five boys and five girls. The second group (aged four to five year-old) included 13 boys and 13 girls. According to the authors, the Cairene dialect has 27 consonants and eight vowels /i/, /a/, /u/, /i:/ , /a:/ , /o:/ , /u:/, /e:/. Syllable structures in the dialect comprise CV, CVC, CVV, CVVC and CVCC.

The authors found that in the first group (three-to four- year- olds), children showed mastery[3] of acquisition of 13 consonants (similar to the Jordanian Arabic sample) /w/, /m/, /f/, /t/, /n/, /l/, /ʃ/ and /j/, /k/, /χ/, /ħ/, /ʔ/, and /h/.

[3]Mastery production: produced accurately in at least 90% of target responses

The remaining consonants were in customary production[4]. The second group (four-to five-year-olds) revealed mastery of 14 consonants, those listed above and in addition the voiced pharyngeal fricative /ʕ/, and customary production of the remaining consonants. Furthermore, in terms of structural processes, they found that four-year olds showed less than 5% cluster simplification or syllable deletion with no final consonant deletion; however, some three-year-olds present with some of those processes.

The study conducted by Saleh *et al.* (2007) on Egyptian children aged between 12 and 30 months revealed that the three categories of processes described by Ingram (1976) occur (i.e. syllable structure processes, substitution processes and assimilation processes); but with the occurrence of weak syllable deletion, glottal replacement, and regressive assimilation, which were frequently identified in the children's speech production. Glottal replacement of uvular plosive is considered to be a normal process in some dialects of Arabic-speaking children and Egyptian dialect-speaking children in particular.

2.5.3 Kuwaiti Arabic

Ayyad and Bernhardt (2009) presented some preliminary information relating to the phonological development in Kuwaiti Arabic from two typically-developing bilingual siblings (ages 2;4 and 5;2) and a six-year-old with sensori-neural hearing loss. Results indicate that the typically developing brothers developed most of the Arabic phonological system with the exception of interdentals. The authors suggested that by age 2;4, it is possible for children to acquire most of the Arabic targets excluding /r/, and weak initial syllables, as well as some vowels which tend to be acquired in the later stages.

[4] Customary production: produced accurately in 50-89% of target responses

When comparing the results of Ayyad and Bernhardt's (2009) study with earlier reports conducted by Amayreh and Dyson (1998; 2000) and Ammar and Morsi (2006), it can be seen that the Kuwaiti siblings have acquired most of the targets earlier than the groups in the latter two studies. Ayyad and Bernhardt commented that the typically developing siblings are bilingual; this could be a reason for stimulating the early acquisition of Arabic consonants in comparison with the findings of the Jordanian and Egyptian reports. Undoubtedly, further studies should be conducted on a large monolingual sample so that phonological acquisition in Kuwait could be examined more thoroughly. It is, however, interesting to consider the effect of bilingualism on Arabic phonological acquisition.

Ayyad (2011) on Kuwaiti Arabic using a nonlinear phonological framework conducted the most recent study on phonological development in Arabic. In this study, Ayyad included 80 typically developing participants with ages ranging from 3;10 to 5;2 years. Children were grouped according to age into 43 participants aged 46-54 months (the younger age group) and 37 participants aged 55-62 months (the older age group). An additional group was added to include those who showed delayed phonological development (the at risk group).

In terms of consonant acquisition by the younger age group, the following consonants were acquired across different word positions as follows:

- Stops /b, bː, t, tːˤ, d, k, g, qː[5], ʔ/, nasals /m,n/, fricatives and affricate /ðˤ, ħ, h, χː, tʃ/, liquid /rː/ and glides /w, j/ were acquired by 90% or more of the participants .
- Stops /tˤ, q/, fricatives /sːˤ, ð, ʃ, ʁ, χ, ʕ/ and the lateral /l/ were acquired by 75% -89% of the children.
- Fricatives /s, sˤ, θ, z/, the affricate /dʒ/ and the trill /r/ were not acquired by the children at a level of 75%.

[5] Ayyad refers to /qː/ as long consonant which indicates germination i.e. [q.qː].

Results for the older age group revealed the following:

- Stops /b, bː, t, tːˤʰ[6], d, k, g, qː, ʔ/, fricatives, affricate /f, ðˤ, ħ, h, χ, ʁ, ʃ, tʃ/, nasals /m,n/, liquids /rː, l/ and glides /w, j, jː/ were acquired by almost 90% of the children in all word positions.
- Fricatives and affricate /θ, ð, dʒ, ʕ/ and the lateral /l/ were acquired by 75% - 89% of the children in all word positions.
- By the age of four, /s,sːˤ,r/ were still not acquired in all word positions by 75% of the children.

Results of consonant acquisition by the at-risk group revealed the following:

- Stops /b, bː, k, g, qː, ʔ/, nasals /m,n/, fricatives /f, χː, h/, liquids and glides /l, w, j, jː/ were acquired by 90% or more in all word positions .
- Stops /t, dː., tː, tːˤʰ/ and fricative /ðˤ/ were acquired in all word positions by 75% -86% of the children.
- The stop /tˤ/ and fricatives /s, sˤ, sːˤ, θ, ð, z, ʃ, χ, ʁ, ʕ, tʃ, dʒ/ and /r/ were still not acquired in all word positions by 75% of the children.

In terms of word shapes:

- Monosyllabic word shapes including CVV, CVC and CVCC were acquired by 90% or more of the children in the 3 groups.
- Disyllabic word shapes including CVCV, CVVCV, and CVCCV were acquired by 90% or more of the children in the three groups.
- Almost all multisyllabic word shapes were acquired by both older and at-risk groups. The younger age group was still in the stage of acquiring word shapes: CVCVCVC, CVCCVCVC, CVCVCVCV, and CVCCVCVCV.

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[6] This symbol /tːˤʰ/ is referred by Ayyad(2011) as long aspirated emphatic stop

2.5.4 Qatari Arabic

Al-Buainain *et al.* (2012) presented baseline data for Arabic acquisition in Qatari children between the ages of 1;4 and 3;7. Her study aimed to present some results about phonological processes observed in the spontaneous speech of 140 monolingual Qatari children. Results of Al-Buainain's *et al.* (2012) study showed the occurrence of three main types of phonological processes; substitution processes, assimilation processes and syllable structure processes.

In terms of substitution processes, the author found the following processes:

- Substitution of /r/ with /l/, a glide, or a vowel. Furthermore, she found that the trill is sometimes deleted or assimilated. (Reported up to age 3; 1).
- Sibilant deviation: sibilants are replaced by interdentals or by dental/alveolar stops (i.e. /s/→[θ], /s/→[t]). (Reported up to age 3; 5).
- Glottal replacement: oral fricatives and plosives are replaced by the glottal stop which is similar to Ammar's (1992) finding (i.e. /ʕ/→[ʔ]).(Reported up to age 3;2).
- Fronting: the author reported the process of velar and palatal fronting in her data (i.e. /k/→[t] , /g/→[d], /ʃ/→[s]).(Reported up to age 3;2).
- Backing: the author noticed replacement of interdental /f/ by velar [g] (/f/ →[g]), which could be argued to be an unusual form of backing. (Reported up to age 2; 2).
- Stopping: the author reported substitution of fricatives and affricate with stop consonants. (i.e. /s/→ [t], /dʒ/→[d]). (Reported up to age 3; 5).

In terms of assimilation processes, the author found the following processes:

- Consonant or vowel harmony (Reported up to age 3; 7).
  e.g. /ħala:wah/→ [wa:wah] 'Candy' consonant harmony
  /dab.du:b/→ [dub.du:b] 'Teddy bear' vowel harmony

In terms of structural simplifications, the author found the following processes:

- Consonant cluster simplification (Reported up to age 2; 8).
  e.g. /kalb/→ [kab] ‘Dog’
- Initial consonant deletion (Reported up to age 4; 2).
  e.g. /χaːliː/→ [aːliː] ‘Uncle’
- Weak syllable deletion (Reported up to age 3; 7).
  e.g. /batˤaːtˤis/→ [tˤaːtˤis] or [taːtis] ‘potato’
- Metathesis (Reported up to age 3; 6).
  e.g. /tˤaːw.lah/ → [tˤaːl.wah] ‘Table’

The aim of the above review of studies is to provide a basis for phonological analysis of both the cleft group and the control group in later chapters.

2.6 Summary of Segmental Acquisition in Arabic

Table 2.3 summarises the consonant inventory of Arabic studies (Jordanian, Egyptian and Kuwaiti). As revealed from Amayreh and Dyson’s (1998) study, Jordanian children acquired the non-emphatic plosives /b, t, d, k/ and some of the fricatives /f,ħ/, nasals and approximants before the age of four (2;0-3;10). Other fricatives including some of the sibilants (i.e./s, ʃ/) and uvulars have been acquired between the ages of four and six as well as the emergence of trill, flap and tap consonants. Emphatic consonants and pharyngeals have not been acquired before the age of 6:5.

In Egyptian studies, results showed that children between the ages of three and four have mastered the production of only two plosives /t, k/, whereas other plosives /b, d ,tˤ, g, dˤ/ have been produced accurately in only 50-89% of target responses. A limited number of fricatives was also acquired in this age group /f, ç, χ, ħ, h/ (i.e. mastery production) and the rest of the fricatives /s, sˤ, z, zˤ, ʁ/ were again produced accurately in only 50-89% of target responses. Nasal and approximants were produced accurately by the children. For the other group (four- to five-year-olds), the same consonants were mastered (i.e. plosives /t, k/, fricatives /f, ç, χ, ħ, h/, nasals /m, n/, approximants /l, w, j/) in addition to the mastery production of pharyngeal plosive / ʕ/.

A comparison of Kuwaiti studies with Jordanian and Egyptian studies reveals that Kuwaiti children were able to acquire most of the consonants at a younger age (i.e. four years old). Hence, before the age of five, the following consonants were acquired by 90% of the children: plosives /b, bː, t, d, tˤ, tːˤʰ, k, g, qː, ʔ/, fricatives /f, ðˤ, sˤ, ʃ, χː, ħ, h, tʃ/ , nasals /m, n/, approximants /w, j, jː/ and trills /r,rː,/.

Table 2-3 Age of acquisition for Arabic consonants

Jordanian	Before the age of 4	plosives /b, t, d, k/, fricatives /f, ħ/, nasals /m, n/, approximants /l, w/
	4-6;4	plosives /b, t, d, k/ , fricatives /f, ħ, s, ʃ, χ, ʁ/ , trill, tap or flap /r, ɾ, ɽ/
	6;6- 8;4	plosives /b, t, d, k, tˤ, dˤ, q, ʔ/ , fricatives /f, ð, θ, z, ðˤ, sˤ, ħ, s, ʃ, ʕ, χ, ʁ /, affricate /dʒ/, trill, tap or flap /r, ɾ, ɽ/
Egyptian	3-4	plosive /t, k/ , fricatives /f, ç, χ, ħ, h/ , nasals /m, n/, approximants /l, w, j/ (Mastery production)
		plosive /b, d, tˤ, g, dˤ/, fricatives /ʕ, s, sˤ, z, zˤ, ʁ/ (Customary production)
	4-5	Plosives /t, k/ , fricatives /f, ç, χ,ʕ, ħ, h/ , nasals /m, n/, approximants /l,w,j / (Mastery production)
		plosive /b, d, tˤ, g, dˤ/, fricatives /s,sˤ, z, zˤ, ʁ/ (Customary production)
Kuwaiti	3.8 – 4.5	Plosives /b, bː, t, d, tˤ, tːˤʰ, k, g, qː,ʔ / , fricatives /f, ðˤ, sˤ, ʃ, χː, ħ, h/, affricate /tʃ/, nasals /m, n/, approximants /w, j, jː/, trills /r, rː,/
	4.6-5.2	plosives /b, bː, t, d, tˤ, tːˤʰ, k, g, qː, ʔ /, fricatives /f, ðˤ, ʃ, χ, ħ, h, tʃ/, nasals /m, n/ ,approximants /w, j, jː/, trills /r, rː,/

2.7 Summary of Phonological Processes in Arabic

A number of phonological processes (structural and systemic) have been used by Arabic children in different studies. The simplifying processes investigated in Arabic studies are summarised in this section and also compared with the case in English.

2.7.1 Substitution processes

1- Stopping: Dyson and Amayreh (2000), Ayyad (2011) and Al-Buainain *et al.*(2012) reported a high number of mismatches for the following consonants /ð, s, dʒ, θ/ across word positions.

2- Fronting: Amayreh and Dyson (2000) found the fronting process occurring only for stops, whereas Ayyad (2011) reported frequent occurring of fronting but only for velar and uvular stops, whereas fronting of fricatives occurs only on a very few occasions. Furthermore, Al- Buainain *et al.* (2012) reported the process of velar and palatal fronting in her data (i.e. /t/→[k] , /g/→[d] ,/ʃ/→[s]).

3- Non-cleft dentalisation: Dyson and Amayreh (2000) and Al-Buainain *et al.*(2012) found the following fricatives were frequently affected by dentalisation (/s, sˤ/→[θ], /z/→[ð]). The same was reported in Ayyad's (2011) study with the addition of the affricate.

4- Glottal stop: the glottal stop has been reported frequently in Jordanian studies (e.g. Dyson and Amayreh, 2000) as a replacement for uvular stop; however this is a feature of the dialect. On the other hand, such replacement was uncommon in the Kuwaiti study done by Ayaad (2011). In Al-Buainain's *et al.*study, the pharyngeal was replaced by glottal stop in children up to age 3; 2 (i.e. /ʕ/→[ʔ]).

5- De-pharyngealisation (de-emphasis): this simplification indicates the loss of the secondary articulation (e.g. /dˤ/→[d]) which has been reported frequently in Jordanian children (Dyson and Amayreh, 2000) and persists up to the age of 4;4, whereas Kuwaiti children were using the secondary articulation by the age of four. Al-Buainain *et al.* (2012) did not report the occurrence of this process in her data.

6- Voicing: Jordanian studies did not report voicing as a part of phonological processes; however, Ammar and Morsi (2006) reported voicing process in Cairine children aged three to five years old. In Kuwait, Ayyad (2011) found devoicing in the younger and the older age groups as well as the at risk group; however, as she stated, '*the older group did only partial devoicing, distinguishing them from the other groups who had full voicing or devoicing for some targets' (*p.160). Al-Buainain *et al.* (2012) reported devoicing in her data in Qatari children aged 2; 2 to 3; 0.

7- Variant production of the trill /r/: Amayreh and Dyson (1998) found only a single replacement for /r/ →[l] (i.e. lateral replacement) which has been acquired in the period of (4;0-6;4), whereas Ayyad (2011) reported all of the following replacements for the trill [ʁ, β, w, ʋ, j, ɹ] in all age groups in her study. Al-Buainain *et al.*(2012) reported substitution of /r/ with /l/, a glide, or a vowel in children in up to the age of 3;1. Furthermore, she found that the trill is sometimes deleted or assimilated.

2.7.2 Word and syllable processes

In Jordanian and Egyptian studies (i.e. Dyson and Amayreh, 2000 and Ammar and Morsi, 2006), structural patterns were generally noted to be low in frequency (e.g. syllable deletion and final consonant deletion), except for sequence reduction and stridency deletion which were noted more frequently in children at the age of 4;4. Similar findings were reported in Kuwaiti children (Ayyad, 2011), where consonant and/or syllable deletion in the unstressed syllable have not been reported frequently, particularly in the case of the younger group and the at-risk group. Final vowel deletion also occurred, but was usually considered as an acceptable variant.

Generally, to report the results of the current study, it is hard to rely on one study (e.g. Kuwaiti) and ignore another (e.g. Egyptian). For example, for the sound /dʒ/, most of Saudi speakers realised it accurately [dʒ] (e.g. [dʒiːb] 'bring'), whereas Kuwaiti speakers use [j] as a replacement for /dʒ/ (e.g. [jiːb]) and Jordanian speakers realise it in the same way as Saudi speakers. Thus, for the affricate consonant, Jordanian studies would be relied on instead of Kuwaiti. On the other hand, most of Saudi speakers realise /θ,ð/ accurately (e.g. /θuːm/→[θuːm] 'garlic'), whereas Egyptians replace them with alveolar consonants [s, z] or [t, d] (e.g. /θuːm/→[tuːm]) and Kuwaiti speakers realise /θ,ð/ in the same way as Saudi speakers. Thus, when looking at the phonological development of /θ, ð/, analysis of findings for the current study would be based on Kuwaiti studies. Thus, analysis of individual sounds may be related to different, appropriate varieties of Arabic.

2.8 Summary of important differences between Arabic and English

It is difficult to compare Arabic findings with the English literature on segmental acquisition, both because considerable differences have been reported in English studies (e.g. see Table 2-3 in Smit, 2007 and Table 27-3 in Howard, 2007) and also because there is relatively little literature published on Arabic speech development. However, Amayreh and Dyson (2000) have made a comparison between findings of Arabic studies and some of English studies and suggested that phonemic acquisition in Arabic is generally similar to those reported in English. For example, stops preceded fricatives and also front consonants acquired before back consonants and these findings supported Jackobson's (1961) theory of universal patterns of acquisition. However, an exception to Jackobson's suggestions occurred in uvular fricatives /χ/ which has been acquired early. The early acquisition of /χ/ supports Ingram (1981a) and Beckman and

Edwards' hypothesis of functional load (2000), which reports that order of acquisition can also reflect the functional load of a phoneme.

Amayreh and Dyson (1998) reported that children before the age of four have developed /b, t, d, k, f, ħ, m, n, l, w/. Although the bilabial stop /b/ is one of the early consonants in Arabic acquisition, Amayreh and Dyson have noticed that /b/ was acquired later in comparison to English studies. The glide and approximant occurred in their study, just as in English, with the /j/ showing higher frequency than /w/.

On the other hand, the following consonants are generally acquired late (i.e. 6;0-8;0) in English /v, θ, ð, z, ʒ, dʒ, l, r/ (Smit, 2007), whereas in Arabic, /dˤ, q,z,ʕ/ were the latest acquired consonants (i.e. 6;6-7;4) together with /tˤ/ (8;4).

For phonological processes, Amayreh and Dyson (1998) compared their findings with some of the English studies (Dyson and Paden, 1983; Khan and Lewis, 1986) and found that final consonant deletion is less common in Arabic than in English. However, in comparison with Preisser *et al*. (1988) final consonant deletion appeared more common than in English. In terms of stopping of fricatives, fronting of back consonants and stridency deletion, Jordanian Arabic and English have the same frequency of occurrence (Ingram *et al*., 1980; Hodson and Paden, 1981; Hare, 1983; Khan and Lewis, 1986 and Preisser *et al*., 1988). In Kuwaiti Arabic, Ayyad (2011) found frequent fronting and dentalisation of fricatives and affricates, whereas, in English, Grunwell (1985) notes minimal fronting after age 3 and labialization of /θ/. Lateralisation of /r/ was one of the most occurring patterns in Arabic studies (e.g. Amayreh and Dyson, 1998; Ayyad, 2011). The same process was reported in English but less commonly (Smith, 1973; Dyson and Paden, 1983; Smit, 1993).

2.9 Summary

The current chapter has reviewed the literature regarding phonological development in English and Arabic speaking children in relation to phonemic acquisition and phonological processes observed in both languages. The information reviewed on phonological processes of different dialects in Arabic shows a number of phonological processes (Amayreh and Dyson, 2000; Saleh *et al*., 2007; Al-Buainain *et al.*, 2012). The most commonly occurring phonological processes are cluster reduction, final consonant deletion, substitution, and assimilation; although it is important to note that findings from the different studies were somewhat inconsistent. Moreover, the chapter has also summarised important differences between Arabic and English in terms of normal phonological development. The next chapter will review the relevant literature on the impact of palatal cleft on the speech production. It will also examine the similarities and differences across languages.

Chapter 3 **Impact of palatal cleft on speech production**

3.1 Introduction

The current chapter reviews some of the relevant literature on the effects of cleft palate on speech production in terms of articulation, phonation, and resonance. The purpose of the chapter is to describe the atypical speech features related to cleft palate. It is divided into five main sections. The first section considers the effect of timing of surgical repair of the cleft palate in minimising the development of speech disorders. In the second part of the chapter, classification of speech related to cleft palate is considered. This involves description of whether the speech production related to cleft palate is phonetic or phonological in nature. The third section considers the articulatory consequences of cleft palate and involves accounts of speech characteristics commonly found in children with cleft palate (passive vs. active). The fourth part deals with atypical phonology related to cleft palate and phonological processes usually found in this group of population. The fifth section provides a summary of speech features found in different languages, with a particular focus on Arabic studies.

3.2 Speech and Palatal Repair

Due to structural abnormality of the oral cavity, children born with cleft palate usually face an exceptional physical challenge in the acquisition of normal speech. Prior to palatal repair, abnormal coupling of the oral and nasal cavity almost always affects the production of speech sounds and also results in an abnormal nasal resonance (e.g. hypernasality). This will inevitably affect the children's communication abilities in the early stages of life which may be demonstrated in terms of linguistic and phonetic developments (e.g. limited sound inventories), limited vocabularies and the occurrence of compensatory articulations (Chapman *et al*., 2003; Scherer *et al*., 2008).

Even with a palatal repair, some children may still demonstrate an abnormal coupling of oral and nasal cavities. This is due to a number of reasons, which might involve the need for a two-stage surgery, including the presence of fistula or unsuccessful repaired velopharyngeal mechanism (i.e. velopharyngeal insufficiency, VPI). Generally, several authors have suggested that early palatal repair is the fundamental key to avoiding the development of compensatory behaviour. Thus, it is better to conduct palatal repair sooner rather than later so that velopharyngeal dysfunction can be prevented (Witzel *et al*., 1984, in Kummer, 2001; Peterson-Falzone, 1996; Chen *et al*., 2012; Abdel-Aziz, 2013).

Palatal repair should be conducted as soon as possible, that is as early as six months of age before the babbling stage (Albery and Russell, 1990; Chapman and Hardin, 1992). Based on an earlier suggestion raised by Dorf and Curtin (1982) raised an earlier suggestion where they noticed that children who had a palatal repair before the first six months of life tend to develop speech normally when compared to children who had their repair during the second half of their first year.

Moreover - and to emphasise the importance of early palatal repair - a more recent study was conducted by Murthy and colleagues (2010) on the effects of palatal repair for children after 10 years of age on all speech parameters including articulation, hypernasality, nasal air emission and speech intelligibility. Although they found improvement in all speech parameters after palatal correction, residual speech problems persist in most patients, who require further evaluation as well as proper treatment. A further recent study conducted by Willadsen (2012) to investigate the effects of timing of palatal closure found that early hard palate closure (i.e. at 12 months) has a positive effect in early speech development for children with cleft palate in comparison with the late hard palate closure (i.e. at 36 months).

For a period of more than 15 years, Rohrich and his colleagues (2000) undertook a comprehensive review of the optimal age of palatal repair not only for a child to acquire normal speech but also to develop normal maxillofacial growth and hearing. They reached the conclusion that it is better to close the soft palate at the age of between three and six months, and then a secondary closure for hard palate should take place between 15 and 18 months of age. With such recommendation, advantage can be taken with the early physiology and growth of the soft palate, which will lead to normal development of speech.

The efficacy of the two-stage palatal repair has been reported in a study conducted by Lohmander *et al.* (2011) where their participants had a repair of the soft palate at the age of five months, followed by hard palate closure at one year of age. Results showed that even with the unrepaired hard palate, early soft palatal repair enables a high number of oral stop consonants. They reported, however, that the cleft group has fewer dentals and oral stops in comparison with the non-cleft group.

Therefore, with all of the given findings, it appears that provided that palatal surgery has been conducted early, particularly during the first year of life, the speech of the child with cleft palate is likely to develop normally. In the coming section, classification of speech associated with cleft palate is considered.

3.3 Classification of Speech Components related to Cleft Palate

Contradictory opinions are found in the cleft literature over the terms used to describe articulation, phonetics and phonology. For example, the terms 'articulatory' and 'phonetics' have been used to mean the same in the literature, whereas McWilliams *et al.* (1984; p.232), for example, commented on the components of cleft speech difficulties as *"the articulatory problems of people with cleft palate may involve phonetics, phonology, or both*". On the other hand, McWilliams *et al.* (1984) and

Stengelhofen (1989) noted that the term ‘phonology’ has been used to describe both articulatory and phonological features. Nowadays, the terms ‘phonetics’ and ‘phonology’ are highly inter-related and cannot be easily separated (Ohala, 1997, 2005).

Harding and Sell (2001) grouped speech difficulties into two categories. The first category involves speech difficulties that occur as a consequence of cognitive issues related to the mental representation and organisation of the phonological system and thus would be classified by Harding and Sell’s classification system as pure ‘phonological disorder’. The second category has been described as an ‘articulatory disorder with phonological consequences’. The latter category involves speech difficulties that are solely related to the structural abnormality linked to cleft palate. Although cognitive organisation and mental representation are intact, these difficulties affect contrasts in meaning and hence have ‘phonological consequences’.

Nevertheless, Howard (2011) stressed the importance of conducting analysis at a phonetic level as a step towards for phonological analysis. Since the effect of inefficient articulatory mechanism on the development of the phonological system is not clear, several authors have highlighted the importance of conducting phonological analysis (e.g. Chapman, 1993; Chapman and Hardin, 1992; Howard, 1993; Grundy and Harding, 1995; Harding and Grunwell, 1996; Russell and Harding, 2001; Howard, 2004; Harding and Howard, 2011). The distinction between the two levels of speech (i.e. phonetics and phonology) is important for preparing a proper intervention plan (Harding and Howard, 2011). In the coming sections, articulatory and phonological consequences of cleft palate are discussed.

3.4 Articulatory Consequences of Cleft Palate

There has been extensive study of cleft speech production where different aspects have been described including articulation, resonance and voice. Speech patterns associated with cleft palate are generally described with reference to nasal resonance, nasal emission and compensatory articulation (Harding and Grunwell, 1998). However, it is important to note that aspects of speech production for individuals with cleft palate are not homogeneous but rather heterogeneous in nature. This is due to the diversity in various factors such as type and severity of cleft palate, dental and/or occlusal status, timing of palatal repair, presence and/or absence of any hearing, developmental or congenital abnormalities.

A number of studies have shown that difficulty of speech production is usually related to the severity of a cleft palate (Grunwell and Sell, 2001). With regard to the type of cleft palate, substantial differences of articulation were noted in a number of studies (e.g. Van Demark and Hardin, 1985; Albery and Grunwell, 1993; Karling *et al.*, 1993; Hardin-Jones and Jones, 2005), where the authors found that children with unilateral and bilateral cleft lip and/or palate presented with more speech errors than children with cleft of the soft palate only. In the latter group (i.e. cleft of soft palate only), Albery and Grunwell reported no errors in dental, palatal or velar places of articulation; whereas unilateral cleft palate involves errors in all places of articulation.

In terms of dental and occlusal factors, Johnson and Sandy (1999) reported that the presence or absence of dental defect does not interfere with the individual's speech. On the other hand, Atkinson and Howard (2011) reported that children who presented with malocclusion do frequently have misarticulations. Dental, alveolar and postalveolar consonants are potentially vulnerable in cases of Class II and Class III occlusions (Giannini *et al.*, 1995; Laitinen *et al.*, 1999). The authors also reported that dental and occlusion status are related to specific types of cleft speech characteristics (i.e. palatalisation or lateralisation).

Harding and Grunwell (1996) listed a number of cleft-type speech characteristics which include dentalisation, lateralisation/lateral articulation, palatalisation/palatal, double articulation, backing to velar and/or uvular, pharyngeal and/or glottal articulation, active nasal fricatives, weak/nasalised consonants, nasal realisations of plosives/fricatives, absent pressure consonants and gliding of fricatives/affricates. Hutters and Brøndsted (1987) and Harding and Grunwell (1998) have made a distinction between these speech characteristics, where they categorised them into two types, “active” and “passive”. A description for each of the two categories and the related speech outcomes is given in the coming section.

3.4.1 Passive cleft speech productions

With specific reference to type of speech abnormalities associated with the structural defect, some individuals with cleft palate do not make any effort to compensate for the structural abnormality related to cleft palate. Therefore, unusual realisations could be perceived as a consequence of abnormal valving of oral and nasal cavities related to velopharyngeal incompetence or oronasal fistulae. It can also be due to the fact that air pressure escape at the pharyngeal port compromises intra-oral pressure (Trost, 1981; Bradely, 1997).

In this case, manner of articulation is usually changed and the airstream is directed from the oral to nasal cavity; and thus problems affecting resonance (i.e. hypernasality, hyponasality) and airflow (i.e. audible and/or inaudible nasal emission) usually arise (Grunwell and Sell, 2001). Weak production of oral consonants can also occur and is thought to be used to reduce nasal resonance (McWilliams *et al*., 1984; Warren *et al*., 1989; Moon and Kuehn, 1997).

Hutters and Brøndsted (1987) and Harding and Grunwell (1998) categorised all of the above mentioned problems as ‘passive’ errors, whereas Trost-Cardamone (1990) described them as ‘obligatory’ errors.

3.4.1.1 Speech outcomes of passive cleft palate strategy

In the cleft palate population, disorders of resonance are most commonly associated with the abnormal function or structure of the velopharyngeal port. *Resonance* refers to the distribution of sound in the nasal cavity whereas *airflow* refers to the amount of air needed to produce speech sounds. When lack of separation occurs between oral and nasal cavities, problems arise including hypernasality (Kummer *et al.*, 1992). On the other hand, hyponasality is usually due to blockage; while mixed nasality could be due to a combination of VPI and e.g. structural anomalies which cause a blockage into the nasal cavity (Kummer, 2001).

Different from resonance disorders related with VPI are disorders related to atypical nasal airflow which includes inappropriate nasal emission and nasal turbulence. The latter two are considered to be articulation disorders rather than resonance disorders. Each abnormality is discussed below in more detail.

a. Hypernasality

Individuals with cleft palate often present with excessive nasal resonance which is known as hypernasality. Studies indicate its rate to be 25-40% in patients with cleft palate (Grunwell *et al.*, 2000, Sell *et al.*, 2001). Such problems of resonance arise primarily due to inadequate closure of the velopharyngeal port during speech. However, it might also be due to the entrance of air into the nasal cavity via an opening (a cleft of the hard palate and/or soft palate) or the presence of fistulae in the hard palate. Hypernasality results in a loss or weakening of air pressure in the oral consonants. Closure of the palatal fistulae should improve the intraoral pressure and as a consequence should result in an improved velopharyngeal movement and thus reduced hypernasality.

Much of the cleft research has focused on the strong effect of velopharyngeal insufficiency and the perception of nasality in the disordered speech. For instance, Edwards (1980) defined ‘cleft palate speech’ as a speech disorder which is characterised by the perception of hypernasal resonance with the production of pharyngeal and glottal sounds as well as many a range of other sounds. Specifically, she described cleft palate speech as the perception of hypernasality due to VPI. However, when hypernasality does indeed occur as a consequence of velopharyngeal insufficiency, severity might relate to the size of the opening (Trost-Cardamone, 1989; Baken and Orlikoff, 2000; Kummer *et al*., 2003; Paniagua *et al*., 2013), where hypernasality is usually related with a moderate to large size opening.

The timing, coordination and movement of the VP ports (e.g. Warren *et al*., 1985; Warren *et al*., 1993) can also determine severity of hypernasality. This can be related to the increased realisation of resonance in connected speech rather than single words in which excessive additional demand is needed to reach the appropriate movement of velopharyngeal valves and thus affects intelligibility. Such abnormality is particularly perceptible on vowels and glides/approximants (Sell *et al*., 1994, 1999). An early study by Andrews and Rutherford (1972) suggested that the perception of hypernasality is greater on high vowels than low vowels.

Furthermore, in earlier studies conducted on normal speakers (e.g. House and Stevens, 1956; Moll, 1962), findings revealed that that high vowels were produced with greater height of velar contact than low vowels. Moll (1962) reported that greater VP gaps were related to low vowels compared to high vowels in a nasal context. Kummer (2001) assumed that this might be related to the location of the tongue in the oral cavity during the production of high vowels whereby it fills the oral cavity for high vowels and thus reduces oral resonance (i.e. the ratio of oral to nasal airflow - sometimes referred to as “ratio theory”). This result increases the impression of hypernasality.

Nasal replacement of target oral sounds can also occur when there is severe hypernasality. In fact, this occurs mostly on voiced plosives e.g. /b,d,g/ in which they are substituted with their nasal equivalent sounds [m,n,ŋ]. What happens here is that the placement of the plosive remains the same but the manner changes from oral to nasal due to increased resonance in the nasal cavity.

b. Hyponasality

Hyponasality/denasality occurs when there is decreased resonance in the nasal cavity due to partial or complete obstruction of the nasal passage or nasopharynx. It particularly affects the production of nasal consonants /m,n, ŋ/ which, in severe cases, the productions might sound like as if they are replaced by their oral cognates [b,d,g]. However, in severe cases and if there is an obstruction to the opening of the oral cavity the problem can also affect the realisation of vowels (Kummer, 2001, Henningsson *et al*., 2009).

The source of hyponasality could be due to enlargement of the nasal passage secondary to a common cold or due to an allergic rhinitis. It can also occur as a result of adenoid hypertrophy which presents frequently in the paediatric population. In the case of the cleft palate population, hyponasality can occur as a consequence of surgical intervention to correct the velopharyngeal dysfunction which may lead to narrowing or reducing the size of the nasaopharyngeal space (Godbout *et al*., 2013). In addition to the mentioned causes, hyponasality can also be due to deviated nasal septum (Lau *et al*., 2013) or even due to maxillary retrusion.

c. Mixed resonance

Mixed resonance occurs when both hypernasality and hyponasality occur simultaneously in the subject’s speech. The sound pattern is mostly perceived in individuals with cleft palate who have a pharyngeal flap or prosthetic devices.

d. Cul-de-sac

Cul-de-sac resonance occurs due to an airflow blockage in the pharyngeal or nasal cavity. The speech is perceived as muffled and has been described as "potato-in-the-mouth" (Kummer, 2001).

e. Nasal emission

Nasal emission can be simply defined as the improper flow of air through the nasal cavity, which can be audible or inaudible. Both types of nasal emission are most clearly observed on production of voiceless sounds which require maximum pulmonary air pressure such as [p,t,k,s,f,ʃ]. It can occur as a result of velopharyngeal insufficiency (Haapanen, 1994) and also due to the presence of palatal fistulae (Stewart *et al*., 2009).

Audible nasal emission is a sound that is perceived when the air passes through a narrow opening in the nasal passages. Inaudible emission is sometimes referred as 'visible nasal emission' because the speakers often produce speech without audible evidence (Peterson-Falzone *et al*., 2001). However, it can be detected by instrumental investigation (Ellis, 1979) or through the mirror test: by asking the speaker to produce pressure sounds while holding a mirror at one or both of the nostrils; thus in the case of inaudible nasal emission, the escape will be visible as a mist on the cold mirror. Although inaudible nasal emission may not obviously interfere with the quality of speech production, it is routinely evaluated as it is considered as one of the indicators of velopharyngeal incompetence or a symptomatic oronasal fistula.

f. Nasal turbulence

As described earlier, nasal emission is perceived as air generated within the nasal passages, while nasal turbulence is perceived as a more distracting nasal noise. Kummer *et al*. (1992, p. 152) indicated that the *'amount of noise generated differentiates several degrees of nasal emission ranging from inaudible nasal emission to the most severe form …labeled nasal turbulence.'* Some authors argue that nasal turbulence (also called nasal rustle) is particularly evident in voiced pressure consonants (e.g. Sell *et al*., 1994) such as [b,d,g]. In contrast, Kummer (2001) suggests that voiceless fricatives are more commonly affected by nasal turbulence as well as nasal emission because *'they are associated with more pressure than their voiced contour parts when the vocal folds attenuate the air pressure somewhat'* (2001,p.159).

Nasal turbulence is associated with a relatively small velopharyngeal gap which results in bubbling secretions above the opening (Kummer *et al*., 1992; Kummer, 2001). Indeed, it can be anticipated that a smaller opening usually results in louder distortion due to the constriction of the airflow which results in turbulence which perceived as friction. Nasal turbulence can be rather loud and intrusive and can mask the production of consonants and thus affect intelligibility of speech.

3.4.2 Active cleft palate strategy

In contrast to the passive speech-related behaviour, other individuals with cleft palate are intentionally or unintentionally using other approaches to circumvent or camouflage the improper escape of air into or through the nasal cavity. Such compensatory behaviours are defined by Hutters and Brøndsted (1987) as 'active' strategies, as compensatory errors in the U.S. system by many American researchers (following Trost, 1981), and by Harding and Grunwell (1998) as 'active cleft type speech characteristics'.

Such characteristics are used to compensate for the structural abnormality caused by palatal cleft and/or fistulae and the problem might continue even after surgical procedure has been taken place (Peterson-Falzone *et al*., 2001). These speech behaviours include glottal stops, pharyngeal fricatives, velar fricatives, posterior nasal fricatives, pharyngeal stops, middorsum palatal stops, double articulations, lateralised articulations, weakly articulated consonants, breathy voice quality, and fricative gliding (Trost, 1981; Hoch *et al*., 1986; Hutters and Brøndsted, 1987; Harding and Grunwell, 1998; 1998; Peterson-Falzone *et al*., 2010; Eshghi *et al*., 2013). Glottal stop realisation is considered to be the most common compensatory articulation produced by children with cleft palate (Peterson-Falzone, 1989; Trost-Cardamone, 1990; Hardin-Jones and Jones, 2005). The latter pattern occurs as a result of the speaker's attempt to produce a sound where there is no loss of air through the nasal cavity (Hikita *et al*., 2013).

As noticed from the type of errors that present, a passive strategy mainly affects the manner of articulation whereas an active strategy is considered as changing the place of articulation (Harding and Grunwell, 1998). The latter authors noted that both strategies can be treated but they need different therapeutic approaches. That is, surgery can treat the cause of passive speech errors. On the other hand, surgery can be used for treating the cause of active errors but since active errors are due to incorrect articulatory behaviours, it is highly likely that the individuals will still use the incorrect articulatory gestures even when the anatomical deficits were treated. Hence speech therapy is needed to target the incorrect articulatory gestures.

3.5 Abnormal voice

Voice is described as dysphonic when a change is noticed in either the voice quality, loudness, pitch or flexibility (Cavalli, 2011). The prevalence of voice problems in individuals with cleft palate appears to be more frequent when compared with typical speakers (Dalston, 1990; McWilliams *et al.,* 1990; Cavalli, 2011). Studies have estimated the rate of voice disorders among cleft palate population to range between 12 per cent and 43 per cent (Brøndsted *et al*., 1984; Grunwell *et al*. 2000; Hocever-Boltezar *et al*., 2006). The nature of the problem is generally perceived as one or more of the following: hoarseness, unusual habitual pitch, breathiness, harshness and reduced loudness.

Although nothing is distinctively identified in a speaker's laryngeal or pharyngeal structures, the existence of a voice problem is best explained as a compensatory laryngeal behavioural adjustment for inadequate velopharyngeal function (Warren, 1986; Guyette *et al*., 2000; Kummer, 2001). Thus, when comparing children with cleft palate to those without clefts, the first group are at higher risk of voice disorders due to the increased laryngeal function and the accompanying decreased vocal quality occur as a compensatory strategy secondary to VPI (Kuehn and Moller, 2000; Van Lierde *et al*.,2004). Laryngeal hyperfunction behaviour can even result in vocal abuse and nodule formation and therefore worsen the speaker's vocal quality.

Hocevar-Boltezar *et al*. (2006) suggested that dysphonia can be related to the presence of conductive hearing loss. The authors report that two thirds of cleft children with muscle tension dysphonia suffered from middle ear problems and half of these children present with hearing loss of more than 30db as well as with ear pathology. In the same study, the authors also found that nocturnal nasal congestion which occurs as a secondary consequence of deviated nasal septum or rhinitis causes dry mouth and laryngeal secretion and all of this result in dysphonia.

Several authors have studied the nature of laryngeal disorders and vocal qualities for speakers with cleft palate. The findings showed wide variations and they appear to be contradictory in terms of voice characteristics in children with cleft palate. For instance, some authors have found a strangled voice quality with excessive tension (McWilliams *et al.*, 1973; D'Antonio *et al*., 1988), whereas others describe a soft or aspirated vocal behaviour

(Bzoch, 1979; McWilliams *et al*., 1969, 1973). A more recent study was conducted by Van Lierde *et al*. (2004) on subjects with cleft palate where they described the phonation as roughness and hoarseness. The latter finding corroborates those of other earlier studies conducted by Brooks *et al*. (1963), McWilliam *et al*. (1973), Leder and Larman (1985), and D'Antonio *et al*. (1988).

As noticed from the above studies, various voice disorders have been reported and it can be suggested that the differences could be due to different strategies used by the children to compensate for the speech disorder. For example, soft voice quality could be used as a strategy to decrease the effect of hypernasality or nasal emission (Peterson-Falzone *et al*., 2001). The authors have also speculated that some children who demonstrate VPI tend to have vocal hyperfunction which increase the risk of developing hoarseness. The variety of voice problems reported is similar to the variety reported for different realisations of speech sounds (i.e. cleft speech characteristics 'CSCs') and reflects the heterogeneity in this population. The divergences noted in the above review of voice disorders add evidence to Howard's (2004:p.313) observation that "*each speaker will, at any point in their development, present with a unique profile of skills and difficulties linked in a complex way to underlying aetiology*". This is due to a combination of factors (including type of surgical intervention, hearing and occlusal status) that underlies aetiology which make individuals different from each other within the same group (e.g. type of cleft palate).

Lastly, a study conducted by Hamming *et al*. (2009) denied the relationship between VPI and the developing of voice disorder. They conducted a study on 185 patients with cleft palate and their findings revealed no relationship between velopharyngeal inadequacy and hoarseness. They suggested that the prevalence of hoarseness among the cleft palate population is similar to normal children and the theory that VPI leads to hoarseness due to compensatory speech behaviours, is inaccurate.

3.6 Phonological consequences of cleft palate

As discussed earlier, phonological development might also be influenced as a consequence of the structural abnormality, which may affect the child's ability to signal phonological contrasts which are essential for meaningful speech. Phonetic abnormality poses a physical challenge in articulating certain sounds in the language, whereas phonological disorders affect the child's ability to signal meaning variations. An example is when the child with palatal clefting is using /g/ as a substitution for all oral target consonants before palatal repair takes place, to compensate for VPI. Following palatal repair, Chapman stated that "*the errors may persist because the child has adopted a rule substituting velar stops for bilabial and alveolar obstruents*" (Chapman, 1993: p. 64). Such an example stresses the previous recommendation on the importance of correcting palatal defect in the first six months of age.

Some authors (Milroy, 1985; Chapman, 1993) suggested that the phonological problems in children with cleft palate are linguistically based and occur as a consequence of difficulty organising the sound system within a language. Others (e.g. D'Antonio and Scherer, 1995; Morris and Ozanne, 2003; D'Antonio and Scherer, 2008) suggested that phonological difficulties exhibited in children with cleft palate are in fact part of an overall delay in expressive language which is common with this population.

A number of phonological processes can also occur in children with cleft palate. Chapman and Hardin (1992) and Chapman (1993), for example, conducted a study to identify the processes that are used in children's speech; some of the processes are directly related to the palatal cleft, while others are considered as a typical phonological development. It is important to note that phonological processes that occur as a normal phonological development tend to persist for a longer period in children with cleft palate than children without cleft palate (Harding and Howard, 2011).

The phonological processes identified in children with cleft palate involve : stopping, backing (i.e. producing consonants with more posterior placement of articulation such as velar, glottal and pharyngeal), initial and final consonant deletions, weak syllable deletion, nasalisation, glottal replacement (i.e. glottal stop is substituted for another consonant), velar assimilation, nasal assimilation and nasal replacement (Powers, 1990; Chapman and Hardin,1992; Chapman ,1993; Grunwell and Harding, 1995; Morris and Ozanne, 2003). It is important to note that some of these processes occur in typical and delayed phonological development in children without a history of cleft palate: such processes include stopping, final consonant deletion and weak syllable deletion. On the other hand, the remaining processes (i.e. backing, initial consonant deletion, nasalisation, glottal replacement, velar assimilation, nasal assimilation and nasal replacement) are usually associated with a history of cleft palate and related hearing impairment.

As reported earlier, some of the above processes can be observed in typically developing children, but again are considered to be more common and persistent in children with cleft palate (Powers, 1990, Harding and Howard, 2011). On this point McWilliams *et al*. (1990) suggested that the most common phonological patterns observed in typically developing children include: unstressed syllable deletion, final consonant deletion, cluster reduction, liquid simplification, assimilation, velar or palatal fronting and stopping.

3.7 What is known about cleft palate speech in other languages?

For the purpose, in this study, of looking at cross-linguistic similarities and differences between cleft speech production in Arabic and other languages, it is necessary to look at what is already known about cross-linguistic similarities and differences across previously reported languages. According to the literature, certain speech features related to cleft palate are considered to be universal regardless of the language being used. This was investigated in the Eurocleft Speech Project (Brøndsted *et al*., 1994). The authors aimed to design a research protocol that would enable comparison of speech of 131 children from five different language backgrounds specifically, English, Danish, Dutch, Norwegian and Swedish. Their first step was to establish an analytical framework that provides phonetic details of the languages and the possible effect of cleft palate on the realisation of these phonetic targets. Based on the findings, the study hypothesised that since some consonants of the languages in the study are similar, speakers may have similar articulatory processes as a compensatory strategy for the structural limitation.

The phonetic framework involves 21 error categories which were categorised into five clusters, namely nasal air flow (i.e. nasal emission, nasalisation, nasal snort, nasal realisations and nasal fricatives), glottal realisations (i.e. glottal realisation and glottal reinforcement), alveolar deviations (backing, palatalisation, retraction, fronting), sibilant deviations (Palatalisation, retraction, fronting, lateral realisations of /s/, [s]-like deviation) and others (e.g. labial deviation, palatal fronting of velars, post-velar realisations , silent articulation of [f] and cluster realisations.

According to the authors, the phonetic framework has provided evidence that speech features related to cleft palate are universal regardless of the language of the speaker with cleft palate. It can be suggested, however, that this conclusion has a limitation as it has been drawn from European languages which have similar phonetic characteristics. It cannot necessarily be generalised to other Languages which have different sounds, phonetic and phonological characteristics, so different articulatory processes may be found (Hutters and Henningsson, 2004). For instance, the Hmong language, which is spoken in one of the Asian countries, has 27 consonants which include some nasal consonants and two nasalised vowels. These nasalised sounds may have a different effect on cleft palate speakers when compared with languages that do not have these sounds (Heimbach, 1980;

Henningsson and Willadsen, 2011). A number of idiosyncratic features have been reported in the literature, including: replacement of /s/ and /f/ with bilabial fricatives [ɸ] (Stokes and Whitehill, 1996; Gibbon *et al.*, 1998), and non-pulmonic sounds (clicks and implosives) (Gibbon *et al*., 2008; Mekonnen, 2013).

Moving now toward the limited Arabic studies on cleft palate speech, one was carried out by Shahin (2006) on three Arabic subjects (from Ramallah, Palestine) with cleft palate. The aim of the study was to investigate whether speech characteristics for Palestinian Arabic children with cleft palate are similar to those reported in other languages. This study is interesting as Arabic has pharyngeal and glottal consonants /ʔ,ʕ,ħ,h/, which are used by speakers with cleft palate from other languages as compensatory articulations (Trost, 1981; Harding and Grunwell,1996). Shahin suggested that the use of these consonants (i.e. pharyngeal and glottals) by Arabic speakers with cleft palate would lead to phonetic neutralisation of phonemic contrasts.

Findings revealed that one of the three children used pharyngeal articulation (i.e. pharyngeal stop[7] /ʡ/) as a compensatory articulation for the velar stop /k/ and two children produced glottal articulation as compensatory replacements for stops only. This is different from Trost-Cardamone's (1997) results on English speaking children with cleft palate where glottal replacement occurred for fricatives and affricates in addition to stops. Additional features have been reported in Shahin's study which have not been reported in previous studies including implosive air stream, oral plosive devoicing and labiodental stopping for /f/. Other characteristics were reported which are common with other languages including: hypernasality, weak articulation, lateralisation, devoicing, backing, glottal replacement,

[7] Although /ʡ/ symbol has been considered on the IPA chart as an epiglottal plosive, it is also used here for the pharyngeal stop as instrumental studies suggest that there is not a strong evidence that the two articulations (i.e. pharyngeal and epiglottal) are distinct (see Esling, 1996).

stopping. As a consequence, Shahin's findings support the conclusion that the characteristics of cleft palate speech are, for the most part similar across languages although there may be some language-specific differences.

The other study contributing to our knowledge of speech development in Arabic-speaking children with a cleft palate is an unpublished dissertation by Al-Awaji (2008) on four Saudi children with cleft palate (i.e. aged 3; 4 to 5; 4). The cleft speech characteristics which have been found in her study include glottal replacement, backing, double articulation, nasal air emission and weak articulation. She also found an additional feature, which she described as an 'idiosyncratic pattern' in one of the children's speech. This was the realisation of target word final trills as velar ejectives. Thus, the child consistently replaced /r/ with [k'] (for instance, [fa:k'] for /fa:r/) in the final position of the word.

This led Al-Awaji to suggest that there are language-specific speech characteristics related to the phonetic and phonological system of Arabic and that further studies are warranted to find whether ejectives are common amongst Arabic children with cleft palate in particular.

When comparing the occurrence of pharyngeal and glottal articulation in Al-Awaji's and Shahin's studies, it is revealed that they both reported the occurrence of glottal articulation but pharyngeal articulation has not been found in Al-Awaji's study. However, it has been noticed that Shahin reported pharyngeal stops but not fricatives and the former is not part of the Arabic phonetic inventory. Therefore, it can be suggested that the occurrence of the pharyngeal stop will not lead to phonetic neutralisation of phonemic contrasts.

A further recent study was conducted by Al-Tamimi *et al*. (2011) on 15 Jordanian children (i.e. aged 4;2 to 6;6) with cleft lip and/or palate. The purpose of the study is to account for different phonological processes exhibited by the children and to identify the productive versus non-productive processes occurring in the speech of the participants. For the process to be grouped as productive, it had to occur five out of 20 times (20%) in the speech of a single participant (McReynolds and Elbert, 1981). Results indicated the occurrence of five productive processes: backing, lateralisation, de-pharyngealisation, stopping and final consonant deletion. Also the study traced other non-productive phonological processes, such as strident deletion, consonant harmony, fronting, syllable reduction, devoicing, liquid gliding and de-affrication.

According to the Al-Tamimi and his colleagues (2011), the most productive phonological process was backing; with /t/ and /k/ being the most affected plosives and /s/, /z/ the most affected fricatives. As in Shahin's (2006) study, the pharyngeal stop (/ʕ/) was used as a replacement for plosives; however this does not result in any disturbance of the phonemic system of Jordanian Arabic nor neutralisation of phonemic contrasts. Glottal stop was also noticed in Al-Tamimi *et al*.'s study and as this consonant is part of Arabic phonemic system it might result in loss of phonemic contrasts. However, the authors have argued that the children are in fact using a creaky glottal stop instead of a complete glottal stop to avoid phonemic neutralisation. Thus, from the findings of their study, the authors suggested that the phonological processes are similar to those found in other European languages; however the only difference observed was on the productivity level of the phonological processes. Results of the Al-Tamimi *et al*. (2011) study showed that backing, final consonant deletion, stopping, lateralisation, and pharyngealisation were the productive phonological processes, whereas backing, final consonant deletion and syllable reduction were the only observed productive phonological processes in two English studies (Chapman, 1993; Chapman and Hardin, 1992).

3.8 Summary

Positive results for speech production indicate the importance of conducting an early palatal repair, according to several studies which were discussed in this chapter, though even with the early palatal repair, speech problems might persist due to a number of possible causes (e.g. residual fistula, VPI etc.). Attempts have been made to describe the effect of palatal cleft on speech output. These speech problems need to be interpreted with care since there are different types of speech associated with cleft palate (i.e. active versus passive). A brief description has been outlined for both types of speech characteristics along with their related speech outcomes.

Cross-linguistic differences in terms of speech outcomes related to cleft palate have been found. This is due to the different sound inventory for each language which needs to be considered to enable comparison between the results reported in a given language with those reported in other languages. In spite of the challenges, it is possible to use the data from speakers of different languages and compare the speech findings across languages. Such comparison can provide knowledge about the vulnerable speech sounds in cleft palate speech, and thus a better understanding could be reached about the nature of speech problems arising from cleft palate.

Consideration of the studies discussed in this chapter has highlighted the issue of how to assess and evaluate speech outcomes in individuals with cleft palate. In the coming chapter, different types of assessment and evaluation of cleft palate speech production features will be discussed.

Chapter 4 **Speech assessment in Cleft Palate Speech**

4.1 Introduction

The role of the speech and language therapist (SLT) is important for children with speech, language and swallowing problems as well as for people with different communication disorders (e.g. stuttering, voice disorders, articulation disorders, aphasia, dysphagia). They are responsible for identification, screening, assessment, interpretation of findings and differential diagnoses. They are also responsible for devising, implementing and revising applicable treatment programs. These steps are important in order to achieve the best intervention strategy and rehabilitation. SLT work closely with parents, carers and other professional such as occupational therapists, nurses, teachers and doctors. They can also work in a variety of settings such as hospitals, schools and other locations in the community.

With cleft lip and palate anomalies, the speech therapist relates the structural abnormality of the cleft to the individual's speech performance. They decide whether the defect needs to be surgically corrected or improved with the use of prosthetics, and they plan the timing and the nature of speech intervention. In order to achieve these goals, effective assessment of the speech mechanism and speech production are essential.

The current chapter focuses on speech assessment in the cleft population starting with perceptual assessment and transcription, and then a consideration of some instrumental approaches related to measurement of speech performance, followed by phonological assessment, and finally a discussion regarding formal assessments of speech characteristics in individuals with a cleft palate.

4.2 Perceptual Speech Assessment

Perceptual assessment of speech is considered to be the basis for speech assessment and the standard clinical procedure for speech and voice disorders in the cleft palate population (Folkins and Moon, 1990; Watson *et al*., 2001). The actual decision of whether the subject has resonance and/or airflow problems or other speech difficulties is based on the listener's subjective judgment (Morley, 1970; McWilliams *et al*., 1990; Sweeney *et al*., 1996; Watson *et al*., 2001).

The general steps in perceptual speech assessment are data sampling, recording, analysis, and interpretation (Grunwell *et al*., 1993). With recording, all speech samples should be gathered in a standardised manner with regard to the setting and recording (Sell, 2005). Audio and/or video recordings should be carried out and used for later analysis. Good quality recordings of speech samples are essential; Gooch *et al*. (2001) stressed their importance along with the listening environment and also the need to ensure uniformity of the amplitude of speech samples. Furthermore, a good quality of recording allows the measurement of intra- and inter-reliability of perceptual speech analysis as well as assessment of different speech quality variables. John *et al*. (2006) also suggested that the nature of the speech recording medium, i.e. analogue or digital, may have an impact on analysis. Nevertheless, nowadays, almost all recordings are digital due to the recent technological advances and widespread access to digital recording devices.

While collecting the data, it is typical for speech sampling in children with cleft palate to involve stimulability, rote speech, sentence and syllable repetition and a sample of conversational speech (Sell, 2005) as well as picture naming as this will give a clear picture of phonetic and phonological ability. As reported by Grunwell *et al*. (1993) and Howard (2011), multi-word utterances and conversational speech are important in that they can provide essential information regarding consistency or deterioration of articulatory performance and changes in resonance features across longer utterances (Kuehn and Moller, 2000). They also provide information on supra-segmental factors such as pitch, loudness and rhythm which affect intelligibility.

On the other hand, sampling of sentences is convenient as it allows the clinician to control the phonetic content of the elicited speech sample (Sell, 2005). John *et al*. (2003) suggested that speech analysis for sentence repetition is much easier as the clinician controls the rate of eliciting the sentences. Furthermore, sentence repetition has an advantage over the reading task whereby the patient can be encouraged to maintain eye contact with the therapist so the facial expressions can be clearly observed during analysis (Sell, 2005).

With cleft palate speech studies, SLTs and researchers need to meet certain criteria for listening procedures including making judgments based on multiple raters, and on recordings that are randomised and blindly assessed. This is important for the enhancement of the value of perceptual studies on this specific population. Sections of the recordings should be repeated in order to allow measurement of intra-rater reliability, to calculate and report intra- and inter-rater reliability (Peterson-Falzone, 1996; Sommerlad *et al*., 2002; Lohmander and Olsson, 2004; Sell, 2005).

4.3 Types of perceptual analysis

4.3.1 Perceptual rating scales

For speech assessment, rating scales judge the severity or degree of specific speech feature such as hypernasality or nasal emission. In the literature, there are several approaches for assessing speech using perceptual rating scales. These include the following:

1. Equal appearing interval (EAI) is the most popular scale for rating different speech parameters (e.g. hypernasality, nasal emission, voice disorder). In this scale, listeners are asked to assign a number into a

linear partition from an equal- interval scale for each aspect of speech being examined. Odd numbers are usually used in this scale, 5-point, 7-points and 9-points (e.g. 'five point scale': 1 = very severe, 2 = severe, 3 = moderate, 4 = mild, 5 = normal). Studies which used this type of scale include, e.g., Konst *et al.* (2003), Workinger and Kent (1991), Hirschberg and Van Demark (1997), Whitehill *et al.* (2002) and Laczi *et al*. (2005).

2. Direct Magnitude Estimation (DME): unlike an Equal Interval scale, a direct magnitude estimation does not require listeners to fit their rating numbers into a linear partition of the speech parameter continuum in question with fixed maximum and minimum numbers at the extreme ends of the continuum. Rather, direct magnitude estimation is a ratio scale that can be used with or without a modulus. When it is used with a modulus, examiners assign a number for a specific speech sample that acts as a standard (modulus) on which other ratings will be based and then listeners are asked to rate all other speech samples in relation to the standard speech sample. On the other hand, when it is used without a modulus, listeners are asked to assign a number by themselves to the speech sample given to them. All other speech samples are valued according to the first rated speech sample (Jones *et al.*, 1990; Whitehill *et al*., 2002).

3. Visual analogue scales (VAS): are used with a scroll bar (for computerised version) of e.g., 100 mm long with predefined extremes of the characteristic being measured. For instance, a degree of hypernasality to be measured using VAS, the left end of the scroll represents normal resonance and the right end represents severe hypernasality (Wewers and Lowe, 1990; Kreiman *et al.*, 1993; Eadie and Doyle, 2002; El Sharkawi *et al*., 2014).

Contradicting opinions are found in the literature regarding the most applicable type of rating scales for evaluating aspects of speech production.

However, selecting a particular rating scale procedure depends on the type of the analysis, qualitative or quantitative. For quantitative studies, for example, some researchers adopted VAS rather than EAI scales as the interval size of EAI may not be equal across the continua (Maier *et al*., 2010).

Stevens (1975) reported great differences in the validity of direct magnitude estimation and interval scaling for the measurement of the two classes of prothetic and metathetic continua. He suggested that a prothetic continuum is additive, whereas metathetic continuum is substitutive. Thus, prothetic stimuli are considered to have a degree of intensity or quantity. That is, an excitation is added to a preexistent excitation. An example of this is loudness where stimulus is perceived as being more or less than a previous stimulus. On the other hand, metathetic stimuli are considered to have a quality rather than a quantity. In the latter, a new excitation is replacing the old one. Pitch would be an example for this stimulus, thus as pitch changes, there is a perceptual variation in quality rather than a quantity.

In cleft palate speech studies, the above mentioned types of rating scales have been used to document the severity level of speech parameters including nasal resonance, nasal airflow, and facial grimace. However, they do not provide information about individual target segments. They can, in a way, indicate improvements e.g. using an 7-point EAI scale to rate overall articulation skills after, for example, a course of speech therapy (Sell and Grunwell, 2001), therefore such information can be best achieved using phonetic transcription which will be described in the next section.

4.3.2 Phonetic Transcription

Phonetic transcription is one of the most commonly used methods for the perceptual assessment of speech production. It involves a system of written symbols used as a way of providing information about individual's speech production, auditory and visual impressions. Thus, it is simply a record of what the observer heard and saw during the production of speech. It has been suggested that a strong relationship occurs between the perception of speech and the occurrence of on-going behaviours of phonation, articulation and resonance. For example, the perception of /t/ implies that vocal fold abduction occurs along with elevation of the tongue tip toward the alveolar ridge (Howard, 2011). However, as Howard (2011) observes, some speakers can produce the same sound but with the use of different articulatory behaviours. So, we need to remember that there is not a one to one relationship between a single auditory percept and a specific set of articulatory movements.

Transcription is considered to be valuable in terms of providing information and a better understanding of the speaker's abilities as well as any difficulties experienced (Shriberg *et al*., 1987; Howard and Heselwood, 2002a). It facilitates the explanation of why a speaker sounds a particular way and what might be done in terms of clinical management.

It is essential to establish clear aims and objectives when using transcription as the focus of the transcription will differ accordingly (Howard, 2011). For example, Howard suggested that the aim of the transcription might be to establish the phonetic parameters for individual's intelligibility. In this case, it is necessary to transcribe individual sound segments as well as voice quality and prosodic features such as stress, pitch, rate and pauses. On the other hand, the aim of phonetic transcription might be to investigate the possible effect of hearing impairment on the individual's speech production. Therefore, when the desired outcome of transcription is clear, the clinician can decide the type, amount of material to be elicited as well as the level and the comprehensiveness of transcription to be made.

4.3.2.1 Types of transcription

It is important to exercising care when choosing the level of transcription that is broad or narrow. The most commonly used type of broad transcription is phonemic transcription. As described by Heselwood and Howard (2008), information about allophonic differences is not included in this transcription system.

On the other hand, narrow phonetic transcription is more appropriate when dealing with individuals with complex speech difficulties and high levels of unintelligible speech. This particularly applies to individuals with cleft palate. In narrow phonetic transcription, more phonetic details are employed by either using more specific symbols and diacritics or by using some allophonic variants (Ladefoged, 2001). Howard (1993) compared broad phonemic and narrow phonetic transcription in order to describe the speech of a young girl with palatal cleft where she found that the child was experiencing severe phonological problems which in broad transcription manifested as the apparent lack of contrasting between /f/ and /v/ sounds in her sound system. However, narrow transcription revealed that the child, in fact, was able to distinguish between the two sounds where /f/ was realised as a weak voiceless labiodental fricative [f͈], while /v/ was produced as strong voiceless labiodental fricative [f͈.] Therefore, it turns out that although the child was able to contrast between the two sounds, the problem lay at an articulatory level in her inability to apply vocal fold vibration along with a fricative stricture in order to produce the required voiced sound. Thus, without narrow transcription, it would not be possible to indicate that the child is, in fact, making a distinction between the two consonants /f / and /v/ even though she was not able to produce /v/ with the vocal fold vibration.

Generally, detailed narrow phonetic transcription, although it is apparently not common clinical practice in the published literature (Lohmander and Olsson, 2004), is considered to be the gold standard in the field, especially for cleft speech (Sell, 2005, Peterson-Falzone *et al*., 2006). It is an important first step in assessment where it forms the foundation for hypothesising about the individual's speech behaviour that can be then analysed and further assessed before and after therapy. Crystal (1987, p.16) recommends that 'if we have made a transcription at the right level for our purposes, it should be unnecessary to have to refer back to the tape in carrying out our analysis later'. Thus, from phonetic transcription, identification of cleft speech features can be made and then classified accordingly into speech features that are related, for example, place of articulation, manner of articulation and/or voicing (Hutters and Brøndsted, 1987; Harding and Grunwell, 1998).

4.3.2.2 Use of Symbols

As mentioned earlier, analysing cleft palate speech requires the use of detailed transcription with a wide range of symbols and diacritics which are not frequently used in transcribing normal speech production (Ball *et al*., 2009). Although special symbols exist for transcribing cleft palate speech (e.g. the symbols developed by Trost, 1981), the most commonly used symbols are the ones in the IPA and ExtIPA for disordered speech (Duckworth *et al*., 1990; IPA, 1999). The IPA and ExtIPA provide the user with a wide range of symbols for transcribing cleft palate speech production, including atypical resonance and airflow. VoQs, the voice quality symbols, are also used for transcription of cleft palate speech, providing symbols for a combination of phonatory and supraglottic settings (Ball *et al*., 1995).

A comprehensive discussion is provided by Heselwood and Howard (2008) on different characteristics of speech production and the appropriate transcription to be used for each characteristic. Additionally, Howard (2011) discussed symbols for the transcription of cleft palate speech using IPA and ExtIPA.

4.3.2.3 Amount of speech sample to be transcribed

There are different opinions in the field regarding the size of the speech sample that needs to be taken for transcription. Traditionally, speech assessment usually consisted of a list of single word responses elicited by picture naming that target consonants in different word positions (Howard, 2011). Recently, awareness has been raised toward the importance of having larger linguistic constructions with more information about the individual's sound production in longer utterances. This has been addressed in assessment tools as in the GOS.SP.ASS and the Scandcleft Project where phonetically-balanced phrases have been used (Sell *et al*., 1999; Lohmander *et al*., 2009), and in spontaneous connected speech (Howard, 2007; Howard *et al*., 2008; Peterson-Falzone *et al*., 2010). Howard (2011) suggests that the ideal way to carry out speech assessment is to gather and analyse a sample of each type of data (i.e. single words responses, phonetically balanced sentences and connected speech). Analysis of a single consonant in single word responses can give the examiner information about the speaker's articulatory abilities in a straightforward way. Moreover, analysing single word production through picture naming, word repetition and nonsense word repetition will give the examiner a better knowledge of the speaker's overall speech processing abilities and difficulties (Vance *et al*., 2005). It might also be essential to analyse articulatory and prosodic aspects in connected speech for individuals who have an overall problem in intelligibility so that a better understanding can be gained of why listeners have a problem in understanding them (Howard, 2007, 2013).

It has been noticed that phonetic and phonological analysis of cleft palate speech is usually focused on the production of consonants, while vowel production is often overlooked. As Gibbon *et al*. (2010) suggested, this could be due to the view that the 'intelligibility of vowel sounds in cleft palate is rarely affected' (Morley, 1970; 53). However, Howard and Heselwood (2002b) shed light on the importance of dealing with a careful transcription of vowels in some cases. For instance, in cleft speech production, some of the vowels will be vulnerable to a degree of hypernasality (Lewis *et al*., 2000) and some vowels may be substituted with nasal consonants within single syllables (Michi *et al*., 1986) or even over whole utterances (Howard, 2004). Furthermore, as there is between vowels and consonant production, vowels may affect consonant production in remarkable ways in atypical speech production and the reverse can also be true (Bates and Jocelynne, 2013).

4.3.2.4 Pitfalls and Problems

Despite the importance of the use of narrow transcription in complex speech, particularly cleft palate speech, there are some arguments in the literature against it. Firstly, some speech therapists may consider narrow transcription as time consuming. However, *'Spending time saves time'* is the view of Perkins and Howard (1995). Although transcription does consume a certain amount of time, it still provides the therapist with extensive and detailed information on voice quality, and segmental and prosodic aspects of speech output. Crystal (1984) argued that spending substantial amounts of time in the initial phases of carrying out an analysis is expected to save time in the overall process of the client's speech management, which will result in more effective management.

A further objection to phonetic transcription is that it is difficult to achieve high validity and reliability. The validity of phonetic transcription mainly focuses on the degree of similarity between (a) perceptual data and data from other sources such as physiologic or acoustic analysis; and (b) perceptual judgements completed in different transcription conditions (e.g. live versus recorded) (Riley *et al.*, 1986; Pye, *et al.*, 1988; Shriberg and Lof, 1991; Cucchiarini, 1996).

Arguments have been raised about the extent of similarity or difference between perceptual and instrumental judgments (e.g., Heselwood, 2009; Howard, 2011; Howard and Heselwood, 2011). In some case, it can be argued that if the results of a transcription do not match with the instrumental evidence; that does not indicate an inaccurate record of the listener's perceptual judgment. Instrumental and perceptual analyses are in fact complementary and provide qualitatively different information about an utterance, rather than competing to validate or invalidate the other (Heselwood, 2009; Howard, 2011; Howard and Heselwood, 2011).

It is logically anticipated that there will be disagreements among the transcriptions (low inter-rater reliability) as when the transcribers are not well trained and when there is an increase in the number of transcribers being compared, a decrease in levels of agreement occurs. This is also true of the degree of narrowness of transcription, as when it increases this leads to a decrease in transcriber agreement. This applies particularly to symbol-to-symbol agreement. However, the perceptions of the transcribers might agree even if their use of symbols does not. Cucchiarini (1996) pointed out that many researchers focused on analysing symbol-to-symbol agreement without trying to take into account the task of evaluating the closeness of actual listener perceptions. Shriberg *et al*. (1984) presented useful strategies on producing consensus transcriptions to overcome difficulties with reliability and agreement. They suggested that the final approved version is achieved through discussion and the application of a set of clear operational procedures.

A further way to overcome problems related to the reliability of transcription is to provide the listeners with intensive and continued phonetic training which should increase the level of agreement. Lohmander and her colleagues (2009) highlighted the importance of agreed conventions and rules as well as the importance of undertaking ongoing training, and updating information. Listeners who are well trained in doing phonetic transcription of the sounds produced by individuals with cleft lip and palate definitely have more capability and reliability when interpreting what they hear, in terms of how articulation can be described and transcribed (Lohmander *et al*., 2009). In this regard Gooch *et al*. (2001) commented that lack of experience in the area of transcription is strongly related to lack of confidence, which has been noticed, by Gooch and her colleagues in many listeners who had attended transcription workshops.

4.4 Formal Assessments

There are a number of assessment protocols that have sections to analyse phonological processes for cleft palate speech. These include GOS.SP.ASS (Sell *et al*., 1994; 1999) which is a national standard assessment for speech associated with cleft palate used in the UK, and the Swedish Articulation and Nasality (SVANTE) tool which provides an assessment for both phonetics and phonology (Lohmander *et al*., 2005). A Norwegian version of the tool has been published recently, SVANTE-N (Lindsjørn and Vethe, 2013). The Swedish and the Norwegian tests are designed to test articulation deviations and nasality in Swedish- and Norwegian-speaking children with structural and/or functional abnormalities in the oral cavity and pharynx against the expected sounds of their languages.

There are additional assessments tests designed for English speaking children which involve more comprehensive phonological analysis but which are not designed specifically for cleft speech production. These include the DEAP (Diagnostic Evaluation of Articulation and Phonology) (Dodd *et al*., 2002) as well as PACS (Grunwell, 1985) and PACSTOYS (Grunwell and Harding, 1995). PACS provides the examiner with multiple options from which to select the proper analysis for a specific child's speech. Grunwell also suggested that the entire analysis might not be appropriate for a particular individual so it is important to select the most useful portions from the PACS. Harding and Howard (2011) have pointed out that the DEAP and PACSTOYS tests are convenient in terms of distinguishing between patterns related to typical development, delayed speech development and those associated with structural patterns related to cleft palate.

When conducting phonological assessment, it is important to have good quality phonetic data and to make narrow transcriptions of various realisations for a given consonant target as this can give information about the variability in the speaker's sound production (Harding and Howard, 2011). Harding and Howard (2011) further highlight the importance of transcriptions for spontaneous speech as this (as Sell *et al*., 1994 commented) can provide information on the individual's phonetic repertoire which might not be present in sentence repetition records.

As already mentioned, responses can be elicited by imitation or spontaneously. However, spontaneous speech might be preferable to imitation as it might reveal information about the child's phonetic repertoire not available from the sentence imitation data (Sell *et al*., 1994). This is clearly important as some children's speech production differs between formal assessment and spontaneous connected speech (Howard, 2007, 2013). In general, Sell *et al. (*1999) and Sell (2005) recommended including different types of speech sample and Kuehn and Moller (2000) supported the need for standardised speech assessment with repeatable and reliable measures.

Over recent years, new methods for assessing, analysing, and recording speech that ease the process of clinical management and also for reporting and comparison of speech results have been developed. For example, the Great Ormond Street Speech Assessment (GOS.SP.ASS 98) is a formal test which has been used by speech and language therapists in the United Kingdom. As commented by Sell *et al*. (1999), GOS.SP.ASS is considered to be a comprehensive speech assessment protocol for speech disorders associated with cleft palate and/or velopharyngeal dysfunction. The test was selected from six different protocols as the best procedure for clinical use as well as for research purposes (Sell *et al*.,1994) and has been translated into German (Bressmann *et al*., 2002). The six protocols were compared under four parameters: ease of use, speed of use, availability of comprehensive information and ease of accessing information from completed forms. Although GOS.SP.ASS was designed specifically to be used for assessing cleft palate and/or velopharyngeal dysfunction, the parameters included can also be used for the assessment of other non-cleft orofacial anomalies. The test can be used from about the age of three years where many children respond to picture stimuli without difficulty and also to the sentence repetition tasks used to obtain the speech sample. Using the test in the clinical setting, the therapist can identify speech features that require additional investigation. By keeping the speech profiles for each patient, the test enables the therapist to measure improvements over time and it also allows comparison between different patients.

The GOS.SP.ASS test facilitates recording of resonance, nasal emission, nasal turbulence, grimace, articulation characteristics and phonation along with a systematic approach to an oral examination, the mirror test and the description of the visual appearance of speech. In addition, further assessment and formulation of a management plan can be conducted.

Resonance, which includes hypernasality and hyponasality and nasal airflow characteristics of nasal emission and nasal turbulence, is evaluated perceptually on the basis of its presence and consistency, as well as degree of severity. Nasal air flow might be evident along with consonants and/or it might replace consonants (i.e. for the latter, the place of articulation is maintained with the air stream directed exclusively nasally rather than orally). Judgments of hypernasality are made on vowels and voiced consonants whereas hyponasality is judged on production of nasal consonants. Nasal emission may be both audible and inaudible and such characteristics are mostly perceived in voiceless consonant productions. In order to detect inaudible nasal emission, the mirror test is used and thus it is included in the GOS.SP.ASS form. Identifying cleft type speech characteristics is also included. This is performed after the phonetic transcription of the target consonant. The way that the sound is realised is then classified according to the nature of the error, as one of the cleft type speech characteristics or as a developmental error.

Despite the usefulness of GOS.SP.ASS as a clinical tool used for perceptual evaluation of speech in the United Kingdom and Ireland, it is considered to be too detailed for the purposes of audit and for the comparisons of speech outcome across centres in the UK. As a result, the Cleft Audit Protocol for Speech – Augmented (CAPS-A) has been developed (John *et al*., 2006). It is shown to be a reliable, valid and acceptable audit tool, and training courses in the use of the tool have been provided for therapists in cleft palate centres in the United Kingdom. The course involves training on phonetic transcription and procedures for capturing and documenting, as well as analysing the data (i.e. thus addressing some of the issues about inter-rater reliability discussed earlier).

CAPS-A uses a colour- coded system of reporting. It consists of 10 sections each representing a different parameter of speech. The parameters consist of: intelligibility, hypernasality, hyponasality, nasal emission, nasal turbulence, grimace, cleft speech characteristics and non-cleft speech errors. CAPS-A is considered to be closely in line with GOS.SP.ASS, however, the former is shorter than the latter and it includes intelligibility as one of the additional parameters to test.

Almost all cleft assessments are in English; however there are a few tests for the analysis of speech production in other languages. One of the few tests available is a protocol test which has recently been published, SVANTE: Svenskt Artikulations och Nasalitets Test (Swedish Test of Articulation and Nasality) (Lohmander *et al*., 2005) for use with Swedish-speaking individuals. Primarily, the assessment is based on choosing one specific target sound for each word or sentence for analysis. Furthermore, another assessment protocol has been proposed specifically for Flemish-speaking patients in favour of evaluating and describing speech, resonance and myofunctional disorders commonly associated with cleft palate and/or velopharyngeal dysfunction in a clinical setting: SISL (ScreeningsInstrument Schisis Leuven) (Breuls *et al*., 2005). This protocol is partially based on the GOS.SP.ASS'98 and has phonetically balanced speech samples as well as sentence samples and normative values for nasometric evaluation. It involves perceptual evaluation of phonetic characteristics, resonance, nasal emission, nasal turbulence, grimace, phonation and intelligibility. It also includes the cold mirror test, nasometry and a myofunctional examination. As with the GOS.SP.ASS, the SISL protocol is designed to specify the patient's treatment needs in terms of assessment, diagnosis and the necessity for further intervention (surgical and/or speech therapy) and investigation. Details about the assessment parameters are provided in Breuls *et al*. (2005).

Other approaches have been developed for the purpose of measurements focussing on the speech symptoms related specifically to the function of the velopharyngeal port. These include the Categorical System of Articulation Problems in Cleft Palate (Ainoda *et al*., 1993, as cited in Fujiwara, 2007) which was developed by the Committee of Cleft Palate Speech in Japan and the Pittsburgh Weighted Speech Scale (PWSS) which rates five characteristics: nasality, nasal emission, compensatory articulations, phonatory characteristics and facial grimace (McWilliams and Phillips, 1979). The two tests mainly focus on velopharyngeal function, paying less attention to the consonant errors. The Temple Street Scale of Nasality and Nasal Airflow Errors (Sweeney, 2000, as cited in Sweeney and Sell, 2008) rates hypernasality, hyponasality and nasal emission but it does not assess consonantal errors at all. The Eurocleft Speech Group (1994, 2000) developed a detailed cross-linguistic phonetic analysis of speech for children after the phase of speech development (around the age of five). The test is therefore inappropriate for use with children when speech is still developing. Many authors have proposed approaches for approval by the international community (e.g. Hirschberg and Van Demark, 1997; Hutters and Henningsson, 1997).

As this review shows, there is an increasing interest in developing and creating procedures for speech assessment in patients with cleft palate and velopharyngeal dysfunction. This is very important in cleft lip and palate management and indeed strongly advisable for permitting comparisons between individual patients, as well as to collect relevant information regarding progression in therapy and to have specific data for research purposes. Furthermore, by developing assessment tests for different languages, comparisons could be made between centres, within languages and across languages.

4.5 Instrumental assessment

While perceptual analysis provides a subjective measurement of speech, instrumental analysis provides objective measures of both structural and functional aspects of speech production. In recognition of the importance of instrumental analysis, Howard and Heselwood (2011; 941) claimed that instrumental analyses “tell us what kind of events in the physical world give rise to what we hear, and this information is invaluable for our general understanding of the phonetic structure of speech and also for informing clinical intervention and remediation”. Instrumental analysis of speech can either give a direct observation of speech production activities or permit indirect inferences about the structure and function of the speech production mechanism. Direct methods include electropalatography (EPG), nasopharyngoscopy, videofluoroscopy, magnetic resonance imaging (MRI), electromagnetic articulography (EMA) and ultrasound. Indirect methods provide an understanding through the data obtained about the processes of speech production and function of the vocal organs, and include aerodynamic analysis and acoustic analysis.

The following section considers some of the above instrumental approaches that are used in the measurement of speech.

4.5.1 Aerodynamic and acoustic objective measures

Over more than 40 years, several instrumental devices have been introduced in order to enhance clinical judgments of velopharyngeal impairment. Acoustic measures of speech include techniques such as spectrography, accelometry and nasometry which all require the movement of vibrational energy through the vocal tract (Moon, 1992). Spectrography is simply defined as a sound analyser with graphic representation that gives the acoustic content of speech sounds. Spectrography shows much promise as an objective and direct evaluation of nasality. However, until recently most acoustic studies of resonance and airflow in individuals with cleft palate adopt qualitative descriptions of the presence of characteristics of abnormal resonance and airflow (Whitehill and Lee, 2008). This is due to the difficulty in measuring the degree of abnormal resonance and airflow using spectrographic analysis. Nevertheless, a number of studies have attempted to use quantitative measures to evaluate nasality in individuals with cleft palate and other speech abnormalities (Chen, 1997; Kataoka, *et al.*, 2001; Rah *et al.*, 2001; Lee *et al.*, 2005; Lee, *et al.*, 2009) using different techniques such as formant analysis and spectral analysis.

Nasometry is a useful technique for the instrumental measurement of nasal resonance and it can be used with children of six years of age and older (Van der Heijden *et al.*, 2011). It is a microcomputer-based instrument which measures acoustic energy that is produced from oral and nasal cavities during speech using two microphones; one of the microphones records the acoustic output from oral cavity, while the other captures nasally-produced acoustic energy. Thus, a measurement is obtained from the two signals from which a nasalance score can be calculated, which represents the ratio of acoustic energy emitted through the nose to the sum of acoustic energy emitted from the nasal and the oral cavities (Kummer, 2001).

Nasalance scores enhance the speech therapist's understanding of hypernasal resonance in individuals with velopharyngeal insufficiency (Dalston *et al.*1991; Watterson *et al.*, 1996). When velopharyngeal closure is not complete, nasal resonance will increase during speech production. Thus higher than normal nasalance scores will be revealed in individuals with VPI when asking them to produce a speech sequences, particularly those that do not include nasal consonants. Studies have shown that factors such as language, dialect and the speech stimuli have an effect on the scores obtained on the Nasometer (Seaver *et al*.,1991, Karnell 1995).

Detailed descriptions of the Nasometer and its application are provided by Kummer (2001) and Peterson-Falzone *et al*. (2001). One drawback of the Nasometer is that there are limited normative data for most of the regional accents in the United Kingdom (Sell and Grunwell, 2001) and this is also the case in Saudi Arabia. The availability of reliable and valid norms of nasometry is essential for clinical use.

Although nasometry is the most commonly used system in clinical settings (Bressmann *et al*., 2006), there are additional instruments which provide the clinician with nasalance scores and have been used clinically (Whitehill and Lee, 2008). These include the OroNasal System and the NasalView. Bressmann *et al*. (2006) compared the nasalance scores obtained from the three mentioned systems (i.e. the Nasometer, the NasalView and the OroNasal System) and concluded that the nasalance scores are not interchangeable and that nasalance magnitudes from the three systems cannot be compared directly.

Aerodynamic techniques involve the measurement of airflows and air pressures in the oral and nasal cavities. Furthermore, it may be used to study velopharyngeal function and to predict the size of the velopharyngeal port (Howard and Heselwood, in press). The techniques have multiple collections that start from simple sensing devices such as manometers and the mirror test to a more sophisticated system using combinations of airflow meters and pressure transducers. The most sophisticated of these is PERCI (the Palatal Efficiency Rated Computed Instantaneously) which was developed by Warren (1979) and which has been refined as the PERCI SARS system; this makes use of pressure transducers (to record airway pressure within the vocal tract) and flowmeters (to record volume rates of airflow). With this technique nasal and oral pressure transducers are employed to measure airflow passing through the nasal and oral cavities.

When a speaker produces a sound or syllable such as [p] or [pa] using the airflow and pressure differences through the two cavities are measured and displayed visually. It has been shown that the PERCI-SARS system is a powerful tool (Moon *et al*., 1993) depicting a good correlation between the perceptual judgment of nasal emission and pressure flow measurement during the production of pressure sounds (Sweeney *et al*., 1999; Sweeney and Sell, 2008; Sweeney, 2011).

Other instrumental investigations are frequently conducted using techniques such as nasopharyngoscopy and multiview videofluoroscopy which provide direct visual evidence of the shape, size, timing and range of movement of the palate and the posterior and lateral walls of the pharynx (Mercer and Pigott, 2001; Sell and Pereire, 2011). All of these investigations are carried out by a specialised Speech and Language Therapist who plays a major role in interpreting and investigating the findings by relating the anatomical structure and function to the patient's speech production. Afterwards, multidisciplinary discussions will determine whether there is a need for a surgery or prosthetic management (Sell *et al*., 2009) and/or the need to intervene with speech and language therapy. During intervention, nasopharyngoscopy and multiview videofluoroscopy can also be used for visual biofeedback therapy to accurately fit speech prosthesis and they are useful in counselling families and in predicting the outcome of the intervention (Sell and Pereira, 2011).

4.5.2 Visual display for consonant production

Electropalatography (EPG) is a technique that has been widely used to study speech errors related to cleft palate. It detects details about tongue-palate contact during speech (Hardcastle *et al*., 1991; Hardcastle and Gibbon, 1997) and provides visual feedback for the resulting speech feature. It is an effective clinical tool that gives information about abnormal articulation in cleft palate speech that may involve errors in place of articulation. The technique has proved its usefulness in terms of diagnosis and treatment of many speech disorders in children (Dent *et al*., 1995; Carter and Edwards, 2004) such as developmental neuromotor difficulties as in dyspraxia (e.g. Lundeborg and McAllister, 2007; Nordberg *et al*., 2011) and dysarthria (e.g. Morgan *et al*., 2007; Kuruvilla *et al*., 2008), hearing impairment (e.g. Bacsfalvi *et al*., 2007; Pickett, 2013), stuttering (e.g. Forster and Hardcastle, 1998) Down's Syndrome (e.g. Wood *et al*., 2009; Timmins *et al*., 2011), in addition to structural abnormalities of the vocal tract including cleft palate (e.g. Fujiwara, 2007; Lee *et al*., 2009).

EPG has been widely used in studies of English and other languages. The use of EPG cross-linguistically is very useful in terms of investigating language-universal in comparison to language-specific aspects of speech disorders. It has been suggested that features of cleft palate speech are similar across languages and that this can be attributed to the structural abnormality of the oral cavity and accordingly, it could be anticipated as occurring universally. However, specific linguistic characteristics of specific languages may affect the type of compensatory articulation implemented by children with cleft palate who acquire their language under unusual circumstances. Conducting studies using EPG with different languages can provide valuable information into the area of cleft palate speech, as there are significant differences in the area of phonology between languages.

Yamashita *et al*. (1992) examined EPG patterns in 53 Japanese speakers with cleft palate, aged four to 20 years. They found that palatal misarticulation is the most frequently occurring EPG pattern in Japanese speakers. This finding corresponds with results of earlier studies (Okazaki *et al*., 1980; Michi *et al*., 1986). Palatal articulation can be defined as tongue-palate contact which involves elevation of the tongue dorsum and middorsum to enable contact with the posterior hard palate. EPG patterns of palatal misarticulations involve contact with the entire surface of the palate, or limited contact with the most posterior region of the hard palate.

With regard to the treatment efficacy of EPG, a study was conducted on a Cantonese-speaking lady who had her palatal repair at the age of 13 (Whitehill *et al*., 1996). After using EPG therapy, an improvement was noticed in the place and manner of articulation with noticeable reduction of her nasal emission. This is interesting as it is already known in the literature that speech therapy for the adult group with cleft palate is very challenging, as their errors have been thought to be already habituated and thus resistant to therapy. However, Lee *et al*. (2009) conducted a Cochrane review on 17 articles to determine the usefulness of EPG treatment in individuals with cleft palate; they found that there is no strong evidence that supports the efficacy of EPG is very low. The authors concluded that the pervasive usage of EPG for treating articulation errors associated with cleft palate cannot be scientifically supported (Lee *et al*., 2009). However, according to the authors, it is important to develop randomised controlled trials before the technique is adopted as part of routine care of individuals with cleft palate.

In terms of EPG investigations in Arabic studies, there are very few studies undertaken on Arabic speakers (Heselwood *et al*., 2013; Heselwood and Watson, 2013; Shitaw, 2013) and none on children with atypical speech production. It would be valuable in future research to look at data from Arabic speakers with cleft palate, to investigate the abnormal patterns of tongue-palate contact already reported in other languages (Gibbon, 2004), as well as for sounds specific to Arabic, including the alveolar trill, and the emphatics. Given that the Arabic sound system contrasts emphatic and non-emphatic consonants, EPG would help in providing information on whether the contact patterns of these two classes of sounds differ in normal speakers. Furthermore, EPG can also provide information on the compensatory articulations and lingual behaviours of emphatics encountered by individuals with cleft palate.

4.6 Sociolinguistic/Sociophonetic Considerations for Speech Assessment

According to an unpublished study at the 8th International Congress on Cleft Palate and Relate Craniofacial Anomalies in Singapore (Hutters and Henningsson, 1997), more than 30 speech and language therapists found that oral pressure sounds are the most vulnerable ones in the speech samples from different languages. Even though they are considered to be the most affected sounds, each language should have its own speech assessment material. This is due to the fact that if a given language has more vulnerable consonants than another language, speech errors in individuals from the former language will be more than those in the latter language. For example, English has 16 pressure consonants in comparison with only two pressure sounds in Hawaiian (Hutters and Henningsson, 2004). Therefore, it could be anticipated that due to different phonetic inventories, English language speakers will demonstrate more compensatory errors than speakers using Hawaiian. Similar findings compared with English might also be hypothesised for Arabic speakers as the latter have many pressure consonants in addition to different places of articulation which include emphatics as well as pharyngeal sounds. Moreover, the number of different vulnerable sounds across languages is not the only factor that affects speech for individuals with cleft palate; but the frequency of their occurrence also plays a major role in a given language (Henningson and Willadsen, 2011).

When conducting the speech evaluation for speakers with cleft palate, it could be worth considering the involvement of speech and language therapists who use the same language as the speaker. The importance of such involvement is found in one of two studies in which Cordero (2008) invited 22 English speaking listeners (eight generalist speech therapists, eight specialist speech therapists and eight naive listeners) to evaluate the presence or absence of speech errors, speech acceptability, hypernasality and velopharyngeal dysfunction in nine speakers with velopharyngeal dysfunction (i.e. speaking English and Spanish) and 13 controls (speaking different languages including English, Spanish and Hmong). The results showed that the English-speaking listeners were more capable of evaluating English speakers rather than Hmong speakers as well as evaluating nasality and velopharyngeal dysfunction in English speakers rather than Spanish. Therefore, in general, listeners were better at judging speakers of their native language rather than other languages and the results also show that acceptability and misarticulations were particularly challenging to evaluate. However, the specialist speech therapists' judgments were superior to the other two categories of listener.

A contradictory finding to the above study appears in a study conducted by Lee and her colleagues (2008) where they investigated the perceptual evaluation of hypernasality in Cantonese speakers by Cantonese and English listeners and found that both sets of listeners ranked speech samples in a similar way. However, such a finding could be due to the recruitment of professional listeners rather than inexpert listeners. Undoubtedly, there is a need for more studies in this area.

To obtain a clear, overall picture of an individual's speech production, it is important to select speech samples to reflect the different phonetic inventories that occur in different languages so that the evaluation of speech can be conducted properly. This is important in terms of the distributional patterns of speech sounds that occur in a specific language so that realisation of individual sounds in different contexts could be determined. Furthermore, the possible influence of cleft palate on speech production from one language to another could be predicted.

4.7 Summary

A review of studies involving speech assessment in the speech production in cleft palate population and issues related were discussed in this chapter. The chapter started with a description of perceptual speech assessment and their types, including perceptual rating scales and phonetic transcription. Types, advantages and limitations of each type of perceptual assessment have been reviewed. The chapter also dealt with a discussion of instrumental analysis and its importance in providing objective information about speech production and the physical characteristics of speech production. Both perceptual and instrumental analysis are important in terms of providing different views of speech analysis and thus they should be used together to validate the findings for each other.

In Chapter 5, aims, design and methods employed for this study will be described. The chapter also addresses the research questions of the study. Furthermore, the reliability of the transcriptions made for this study is discussed.

Chapter 5 **Methodology**

5.1 Introduction

In this chapter, the methodological approach applied in this study will be discussed. The first section of the chapter involves the main aims of the study. This is followed by addressing the research questions. Then, the design and the method employed in the three stages of the study are described. The last section involves a discussion about the steps used for assessing reliability of transcriptions.

5.2 Main aims of the study

- To develop a speech assessment protocol to be used with Arabic-speaking children with cleft palate

- To identify the speech characteristics of Arabic-speaking children with cleft palate from Saudi Arabia

5.3 Research questions

1. What are the speech development patterns found in typically-developing children and children with cleft palate in Arabic; and how do the results of this study relate to findings in other studies?
2. What are the cleft speech characteristics found in the speech of the Arabic children with cleft palate and how they are related to findings in other languages? Are there any patterns which have not previously been reported in the literature?

- Overall, are voiced segments more affected than voiceless segments in children with cleft palate? This is due to the tendency of children with cleft palate to develop voiceless before voiced consonants (Harding and Grunwell, 1998).

- Which are the most and least accurately produced consonants in cleft speech in Arabic-speaking children, and how do the results of the current study relate to previous findings?
- What are the most and least affected manners/places of articulation and how are these related to findings of previous studies?

3. How is age of participants, age at repair and cleft type related to their speech production and how is this related to findings of previous studies?
4. Is there any significant inter- or intra-speaker phonetic and phonological variability observable in the data and if so, is it conditioned by word position and/or elicitation mode?

The first two questions are dealt with in Chapter 7 and 8, question 3 in Chapter 8 and the fourth question in Chapter 9.

5.4 Design and method

The present study employed a descriptive research design which involved a perceptual phonetic and phonological analysis of the speech production of Arabic-speaking children with cleft palate living in Riyadh, Saudi Arabia, and comparing this to the speech of 4 year-old typically developing children.

The study was divided into three categories:
Stage one: Pilot study ‘I’
Stage two: Pilot study ‘II’
Stage three: Main study

5.4.1 Stage one: Pilot study 'I'

In order to check the suitability of the test words and sentences as well as the test pictures, a small pilot study was conducted in the UK prior to a further pilot study and the main data collection in Saudi Arabia.

5.4.1.1 Ethics

The following documents were first approved from the University of Sheffield: initial letter, consent forms and information sheets and then sent the documents to the parents to obtain their permission to conduct the research (N.B. All of the forms were translated into Arabic).

5.4.1.2 Data collection

a. Identification of participants

Children at the age of 4 were approached through the Saudi club members in Sheffield. Children's parents were contacted by either telephone or email and the aim of the study was described. If they showed interest in participating in the study, they were given an information sheet and then were asked to sign the consent form (See Appendix 2 for an example if an information sheet and consent form).

b. Participants

Three four-year-old Arabic speaking children, of Saudi origin (one boy and two girls) were asked to name the pictures for words and to repeat the sentences. The children were all native to Sheffield, and thus they were exposed to English on a daily basis and, used it with Arabic interchangeably. Therefore they could be considered to be bilingual; one of them uses English fluently as a first language.

c. Testing method

The children were assessed individually in a quiet clinic room at the Department of Human Communication Sciences, University of Sheffield. The whole session took approximately 35-40 minutes.

d. Recording method

The test sessions were recorded using a high quality video recorder and MARANTZ PMD 671 audio recorder was used. A microphone Beyer M58 was used and maintained approximately 15 cm from the child's mouth.

e. Material

A preliminary speech assessment tool was created to collect the data. The test includes a list of 83 single words and 27 sentences for elicitation and repetition respectively designed to elicit the consonants of Arabic in different word positions.

f. Elicitation procedure

Children were asked to name the pictures spontaneously to elicit the target single words. If the child did not recognise the picture, choices were given (i.e. is this a lemon (target) or an apple?). If the child still did not respond, repetition was finally used (e.g. can you say lemon?). Sentences could not be elicited due to language limitations, as will be explained thoroughly in the coming section.

5.4.1.3 Results of the pilot study I

The main outcome of the first pilot study was that it was unsatisfactory for the purposes of the main study. This is due to the following reasons:

The pictures:

- Identifying shapes (e.g. circle, triangle), some numbers (e.g. eight and ten) and colours (e.g. red, yellow, brown) seemed to be difficult for a four-year-old child, as this was the case with two of the children.
- Some of the pictures were unfamiliar for a Saudi child living in Sheffield and/or UK (i.e. Mosque, Shumaq 'Saudi uniform') or not commonly used especially with the British environment/ weather (i.e. Air conditioner), or
- Some of the pictures were not commonly used by the children's family or not frequently seen by the child (i.e. ring, Hedgehog, Eyelash, thread, Olive, Turtle).

With regard to the sentences, some of them were difficult for the child to produce even though this was done by imitation. Thus, the child failed in their production by either stopping in the middle of the sentence or producing the wrong words. The first language English speaker could not produce any of the sentences. The reasons behind that might be that some of the sentences are long or linguistically complex or because they were designed using Modern Standard Arabic (MSA). MSA seems to be difficult for a four year-old child as children in Saudi Arabia are usually exposed to MSA after the age of school entrance that is 7 years old.

Thus, pilot I indicated:

- The need to rerun the test on a monolingual Arabic child in Saudi Arabia, to avoid the problems encountered in the original pilot.
- Some test words, pictures and sentences needed to be changed to overcome the above faced challenges.
- A crucial point to bear in mind is that cultural differences should be valued when designing the test.
- The inclusion for the second pilot study involve: typically developing children, age 4-6 ,monolingual Saudi Arabic children

- The second pilot study involve excluding any identified developmental difficulties or medical conditions which could impact on speech development.

5.4.2 Stage two: Pilot study 'II'

- The aim of the second mini stage of the study is to check, scan and confirm the suitability of the revised test materials including pictures, words and sentences and also to overcome the number of limitations that were found in the initial pilot study. Tested words and sentences were modified in such a way to suit Saudi children at the age of 4 who live in Saudi Arabia. Sentences, in particular, were changed from MSA to Saudi Arabic dialect.

- All of the above inclusion and exclusion criteria were applied upon selection of children participated in this pilot study.

- Five children were recruited and the same elicitation procedure as previously was used to elicit single words and sentences. As the aim of such piloting is to recheck the suitability of the tested materials, participants were recruited from children of friends and family.

5.4.2.1 Results of pilot study II

The revised test material proved to be more suitable for the children (See Appendix 3 for single words and sentences). In addition, the modified sentences (from MSA to Saudi Arabic) were easier to for the children to imitate. These positive results provided a firm basis for the main study.

5.4.3 Stage three: main study

5.4.3.1 Ethics

Children with cleft palate were recruited from two hospitals located in the capital Riyadh. The control group of typically-developing children were recruited from a school in Riyadh. To obtain the approval from the hospitals and the school, the following documents were first approved by the University of Sheffield: initial letter, consent forms and information sheets (see Appendix 2). The researcher then handed the documents in personally to the hospitals and the school in order to obtain permission to conduct the research. Different versions of the consent form and information sheet were written for the cleft palate group and the control group, and then translated into Arabic. These documents along with the approval letters from the hospitals and the school were submitted again to the Saudi Embassy in London and to the Ministry of Higher Education in Riyadh in order to seek their approval to conduct the study in Saudi Arabia.

5.4.3.2 Data collection

a. Participants

Twenty-one monolingual Arabic speaking children aged between 4 and 7, with repaired palatal cleft and four typically-developing four-year-old controls are included in the study (details of the participants in both groups are given in Tables 5-1, 5-2 and 5-3).

Recruiting only four participants from the control group is a realistic number in terms of providing control data for the children with cleft palate. On the other hand, the point of choosing the age of four years for the control group is that by that age the phonological repertoire is almost acquired as studies have shown in English (Smit *et al*., 1990) and Jordanian Arabic (Amayreh and Dyson, 1998), thus minimising the possibility of interference from typical developmental phonological processes. Furthermore, by four years of age children should be 100% intelligible to parents and people outside the family (Flipsen, 2006). At the same time, selecting that age can, at least, provide a snapshot of baseline for typical speakers, which means that speech of children with cleft palate could be evaluated in terms of developmental delays and disorders.

Regarding the matching criteria for both groups, they are both mono-lingual Saudi Arabic, and the age of the control group is matched to the youngest age of the cleft group.

b. Identification of participants

Participants with cleft palate were identified by a specialist speech and language therapist, from children referred to the speech and language therapy clinics for cleft lip and palate in the Military hospital and the Security Forces hospital.

With the help of the speech and language therapist, parents of all children with cleft palate meeting the inclusion and exclusion criteria were approached by the Chief Investigator. Those who expressed interest in taking part in the study were provided with information sheets describing the study and what their involvement entailed.

Participants in the control group were identified by the Chief Investigator with the help of the teachers at the school. Parents were given information sheets and those who were interested in their children participating in the study replied to the Chief Investigator by telephone or by email.

Table 5-1 Participant characteristics

Children's variables	*n*	Mean	SD	Min-Max
Age at assessment (months)	21	66.7	12.9	48-87
Age at repair (months)	21	15.2	4.9	8 -24
Children variables	***n***	**Percentage (%)**		
Type of Cleft				
UCLP	5	23.80%		
BCLP	4	19.04%		
SPO	3	14.2%		
UCP	5	23.80%		
BCP	4	19.04%		
Gender				
Male	10	47.62%		
Female	11	52.38%		

* BCLP =bilateral cleft lip and palate; BCP =bilateral cleft palate; UCLP=unilateral cleft lip and palate; UCP=unilateral cleft palate; SPO=cleft of the soft palate only

Table 5-2 Participants (biological sex ,age at assessment, age at repair and cleft type)

Child Initial	Biological sex	Age at assessment (in months)	Age at repair (in months)	Type of cleft
Da	F	48	15	SPO
Ma	M	48	8	BCLP
Nah	F	48	22	UCP
Mu	M	50	10	UCLP
AM	M	57	12	BCP
Os	M	57	22	SPO
Mis	M	60	19	UCLP
Sh	F	61	24	BCP
Di	F	64	23	BCP
Mon	F	64	15	BCLP
Ta	M	64	9	UCP
Sa	M	67	12	UCLP
Ju	F	68	15	SPO
Sau	M	70	16	BCLP
Jo	F	79	14	UCP
Re	F	79	9	UCP
Gh	F	80	10	UCP
Nas	F	81	16	BCP
AG	M	84	12	UCLP
Moh	M	84	15	UCLP
Me	F	87	21	BCLP

Table 5-3 Demographic data on the four typically-developing children (Control group).

Child Name	Biological sex	Age (in months)
Wanas	F	50
Manar	F	52
Aseel	F	53
Abdullah	M	56

c. Recruitment

The Chief Investigator arranged with the parents who expressed interest for their child to participate to meet with them in the hospital (cleft group) or school (control group) to discuss the research, answer any questions they may have and to provide them with a consent form. All potential participants (cleft palate and control groups) had two weeks to decide if they would like to participate.

The children with cleft palate were recruited according to the following criteria:

1. The age range from four to seven years.
2. First language is Arabic. No other language spoken at home.
3. Children with cleft palate with or without cleft lip.
4. Palatal repair conducted by the age of 12-18 months.
5. No restriction is made on the basis of surgical management, as the study is not looking at the effect of different surgical technique on the speech.
6. No significant hearing impairment.
7. No accompanying congenital syndrome.
8. No other developmental difficulties.

The typically developing children were recruited according to the following criteria:

I. Age: 4 years.
II. First Language is Arabic. No other language spoken at home.
III. No history of any developmental difficulties or medical conditions, which could impact on speech development.

d. Location of the study

All children with cleft palate were recruited from two hospitals (Military hospital and Security Forces hospital) located in Riyadh. The control group was recruited from one of the kindergartens.

e. Duration

The data collection took 2 months (September and October 2011). The duration involved a second pilot study as well as the main study.

f. Testing method

Lists of Saudi Arabic single words and sentences were used to collect a speech sample from each child. This was done by the Chief Investigator, a native speaker of Saudi Arabic. Testing time for each child ranged from 20-30 minutes. A toy was given to each child after the completion of the testing session.

g. Recording method

Responses were video and audio recorded using Olympus DM-450-Digital voice recorder and Sony DCR-SX65E video recorder. The test was done in a quiet room either in the hospital (i.e. for children with cleft palate) or the school (i.e. for control group). All data were exported from the digital recorder and the video camera to a laptop, then a copy was made onto an external hard disk and an additional copy was given to the supervisor for safe backup.

h. Material

A speech assessment tool (henceforth GOS.SP.ASS Saudi Arabic) was designed for the description of cleft speech in Arabic based on the GOS.SP.ASS (Sell *et al.*, 1994, 1999), which is a standard assessment tool for cleft speech used in the UK and is English-based. The Arabic test includes a list of 83 single words and 27 sentences for elicitation and repetition respectively (See Appendix 3). Both were designed to elicit the consonants of Arabic in different word positions. Pictures were devised to elicit the words and to accompany the sentences. The stimulus words and sentences were chosen to be imageable and commonly used in the lexicon of Saudi children, regardless of the region of Saudi Arabia from which the subjects come. A few consonants (/ð,ðˤ,w/) were not included in the test due to their infrequent use and infrequent occurrence in words (particularly in word final position), but otherwise the test was devised to elicit all Arabic consonants in all word positions.

i. Elicitation procedure

In the single word condition, the child was encouraged to name each picture spontaneously, in order to elicit the target single word. If the child did not recognise the picture, options were given first in the form of "is this a **Lemon** (the target) or **Apple**" or a description is used in the form of (it is a yellow fruit that has a sour taste). Implementation of cues and prompts was consistent for the test words across all participants (e.g. a yellow fruit that has a sour taste, we call it …? If the child still did not respond, direct imitation was used as a last resort, e.g. "can you say lemon?").

Furthermore, 27 sentences were designed to elicit the consonants of Arabic in different word positions. To elicit the sentences, the examiner read out the target sentence related to the picture, after which the child was asked to repeat the sentence exactly as presented. If the child did not respond, or only repeated part of the sentence, the examiner repeats the sentence slowly and then asks the child to repeat it again. If the child still struggled to repeat the sentence, the examiner inserted pauses to break the flow of the sentence while asking the child to repeat after the examiner. As noticed, breaking the words as a primary step has facilitated the production of the sentence as a whole.

Before the start of the test, clear instructions were given to the caregiver and the child. Establishing rapport was necessary for especially shy children. The child was rewarded upon completion of the test (i.e. toy). It was noticed that drawing the attention of a child to the presence of a reward upon their completion of the test had a great reinforcement for them.

5.4.3.3 Data analysis

For the list of single words transcription of the whole word was carried out, whereas for the list of sentences transcription was of the target segments only, rather than the whole sentence. For both single words and sentences, transcriptions were done using the International Phonetic Alphabet (IPA; IPA 1999), the Extensions to the IPA for the transcription of atypical speech (ExtIPA; Duckworth *et al.*, 1990; Ball *et al.*, 1994) and Voice Quality Symbols (VoQS; Ball *et al.*, 1995), in order to capture as much information as possible about the child's speech production.

5.5 Reliability

The inter-rater reliability approach has been adopted in this study as it reflects clinical practice (Hayden and Klimacka, 2000; Sell, 2005) and it also has an essential implications for the validity of the study results (Stemler, 2004).

I. The transcriber

A colleague was chosen from the department of Human Communication Sciences, Sheffield, to carry out transcription for the purpose of assessing transcription reliability for the study. She was a native speaker of Arabic, and a qualified speech and language therapist with training and professional experience in doing transcriptions for clinical purposes using IPA, Ext IPA and VoQs symbols. In order to assess the reliability of the transcriptions conducted by the chief investigator in the present study, the transcriber received additional specific training to do transcriptions of speech production related to cleft palate. Training was done by providing the transcriber with a training material (discussed in the coming section). She also attended Masters level modules on speech analysis in cleft palate, which are available in the Human Communication Sciences Department at the University of Sheffield.

II. Preparing the training material

The training material includes the following items: 1) The training Videos from the original GOS.SP.ASS'98 (Great Ormond Street Speech Assessment) and 2) The training Audios and Videos from the Saudi Arabian GOS.SP.ASS.

The purpose of providing videos from the original GOS.SP.ASS was to provide ear- and visual- training about the specific speech characteristics related to cleft palate and therefore to facilitate making transcriptions. Although the original GOS.SP.ASS video uses English data, the phonetic features (e.g. nasal turbulence, double articulations, etc.) can be usefully compared across languages.

Furthermore, video and audio samples of the full range of cleft type characteristics (as listed in the GOS.SP.ASS) which had been identified in the current study were extracted and embedded in PowerPoint slide shows. The individual video clips were accompanied by a written description for the cleft palate speech characteristics which were identified in the data and included resonance, nasal emission, nasal turbulence, and grimace and other cleft palate characteristics, including dentalisation, lateral articulation, palatal articulation, double articulation, backing, and glottal articulation. Speech samples used in the training material were transcribed by the chief investigator and then checked by the first supervisor, Professor Sara Howard (both transcribers have specific training and experience in transcribing cleft palate speech). Clear and archetypal examples were selected by both transcribers to optimise training and agreement was made on the transcription by discussion. Afterwards, the material was included in the training presentation, which when complete was sent to the transcriber along with guidelines for transcription exercise (for guidelines see Appendix 4). Figure 5-1 is a screenshot for one of the PowerPoint slides used to train the transcriber.

The transcriber was given one month to read and go through the training material carefully and then the chief investigator met up with the transcriber to answer any questions the transcriber had.

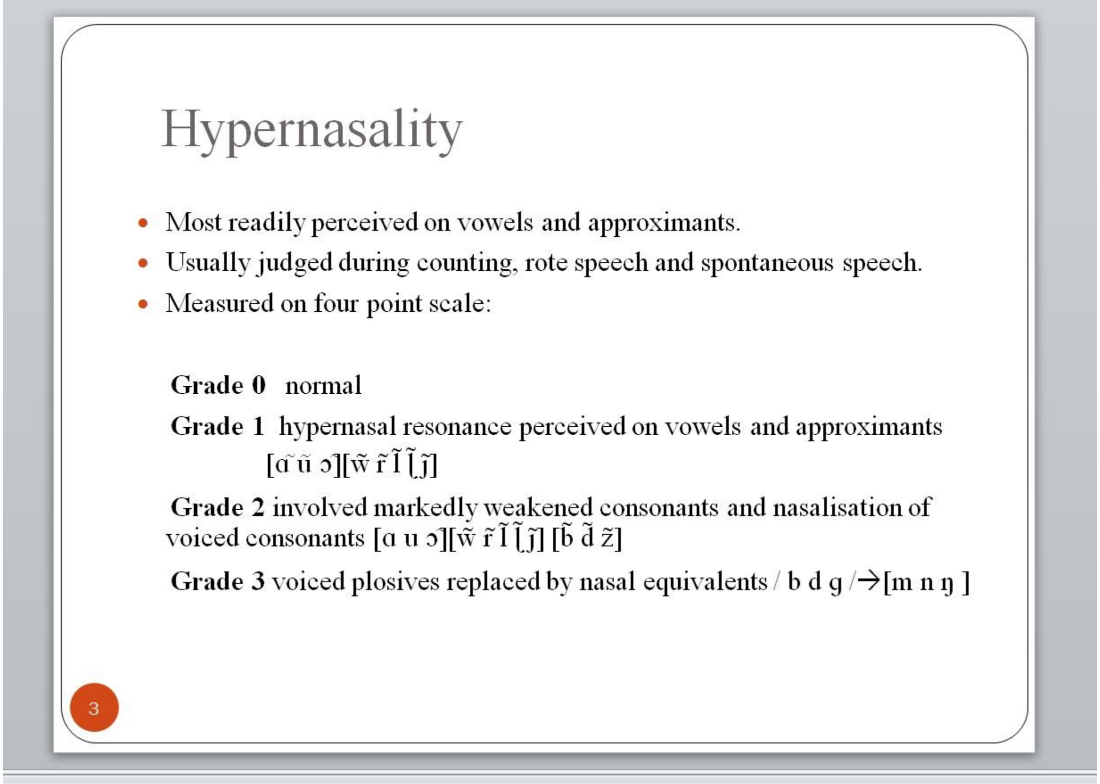


Figure 5-1 An example for one of the slides of PowerPoint used for training

III. The questions

After this phase, audio and video clips containing sentences produced by two children with speech associated with cleft palate were provided to start transcription. The decision to use the speech sample of two children was made based on the 10% typical amount of speech sample usually used for transcription reliability in different cleft palate studies (Shriberg and Lof, 1991; Stokes and To, 2002; Campebell *et al.*, 2003; Salas-Provance *et al.*, 2003; Persson *et al*., 2006; Edwards and Beckman, 2008; Gozzard *et al*., 2008 ; Tyler *et al*., 2011; Lohmander *et al*., 2011).

5.5.1 Reliability assessment

I. The transcription processes

The transcriber was instructed to:

- Use narrow transcriptions using the International Phonetic Alphabet symbols (IPA), ExtIPA symbols for disordered speech (ExtIPA) and Voice Quality Symbols (VoQS), as appropriate.
- Use high-quality headphones for the transcription exercise.

II. Calculation

There are a number of different ways to calculate the transcription agreement. Percentage agreement (i.e. point-to-point) is the most frequently used formula which involves the ratio of the number of agreements divided by the number of consonants. A number of different cleft studies have used this method to provide estimations for transcription reliability (e.g. Hardin-Jones and Jones, 2005; Persson *et al*., 2006; Hardin-Jones and Chapman, 2008; Chapman *et al*., 2008; Lohmander *et al*., 2011; Magnus *et al*., 2011).

Point- to point- agreement has, however, a number of limitations. Cucchiarini (1996) listed three main limitations of percentage agreement: 1) it is derived from the notion that agreement between transcription symbols is *all-or-none;* 2) results can be influenced by chance agreement; 3) it does not consider additional or deleted segments. For instance, for the Arabic word /bint/ ‘girl’, transcriber X may transcribe it as [bin], while transcriber Y may transcribe it as [bint̚ʔ]. Using point-to–point comparison will be difficult in such case as the omitted consonant [t] in the first transcription would not be accounted for, nor the added consonants in the second transcription [ʔ].

To overcome the above mentioned limitations, Cucchiarini (1996) suggested another approach, named the weighted approach. In this technique different weights are assigned to different types of agreements or disagreements based on the degree of similarity between speech sounds. Although the weighted approach technique has been adopted by a number of studies (e.g. Ingram, 2002; Ramsdell *et al.*, 2007), it has some limitations related to measuring the extent of similarities and differences between speech sounds (Cucchiarini, 1996).

Having discussed the limitations for the above techniques, Mekonnen (2013) created a novel approach to analyse the inter-judge reliability. After receiving training from using this technique from the author, Mekonnen's (2013) approach to measuring consonantal transcription agreement was adopted in this study with a few further adaptations made to suit the design of the current study, as described in the forthcoming section.

III. The analysis

Based on Mekonnen's (2013) approach, a 5-point scale was used (0=complete disagreement, 1=little agreement, 2=partial agreement, 3=little disagreement, 4=complete agreement) to assign degrees of transcription agreement/disagreement for consonantal productions. Table 5-4 and Table 5.5 provide a list of phonetic features that were targeted for the reliability exercise and the categories used for conveying each level of transcription agreement.

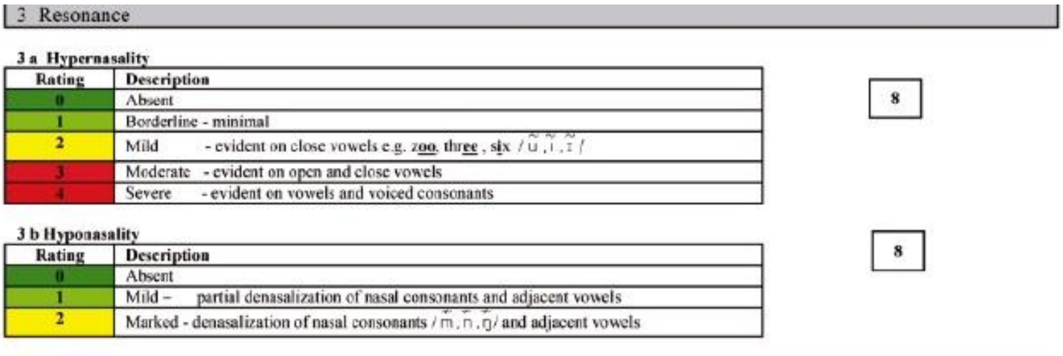
Table 5-4Segmental features considered in the rating of degree of agreement (Adapted from Mekonnen, 2013:109)

Segments	Core features	Other articulatory features
Consonants	• Place of articulation • Manner of articulation • Airstream mechanism • Voicing • Accompanying resonance and airflow	Secondary articulatory feature (e.g. palatalisation and lateralisation)

Table 5-5 Definitions of the types used for allocating degrees of agreement /disagreement (adapted from Mekonnen, 2013:110)

Consonants	
Scale attributed	***Features to be considered***
Complete agreement	When there is a complete one-to one-match
Little disagreement	When two transcription share all the core features but do not share the '*other articulatory'* features
Partial agreement	When two transcriptions share 4 of the core features and do not share the '*other articulatory'* features.
Little agreement	When two transcriptions share less than 4 of the 5 core features and do not share the 'other articulatory' features
Complete disagreement	When two transcriptions share none of the core features

Measuring resonance and airflow was conducted using the scale points used in the CAPS-A (John *et al*., 2006; See figure 5-2 and figure 5-3) rather than the one adopted in the Saudi Arabian version of GOS.SP.ASS (See Appendix 3). This is because it has been suggested that increasing the number of rating scales would be more accurate when testing reliability as less scale points would increase the tendency of having more reliability agreement (McWilliams *et al*., 1990).



3 Resonance

3 a Hypernasality

Rating	Description
0	Absent
1	Borderline - minimal
2	Mild - evident on close vowels e.g. zoo, three, six / ũ, ĩ, ɪ̃ /
3	Moderate - evident on open and close vowels
4	Severe - evident on vowels and voiced consonants

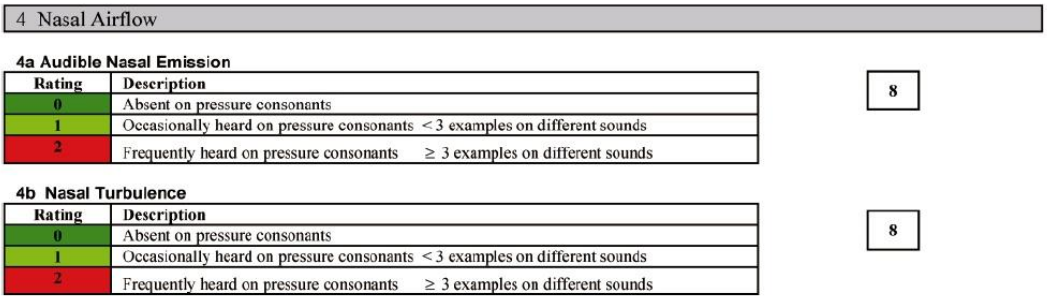
8

3 b Hyponasality

Rating	Description
0	Absent
1	Mild – partial denasalization of nasal consonants and adjacent vowels
2	Marked - denasalization of nasal consonants / m, n, ŋ / and adjacent vowels

8

Figure 5-2 Scale points used in the CAPS-A to measure resonance



4 Nasal Airflow

4a Audible Nasal Emission

Rating	Description
0	Absent on pressure consonants
1	Occasionally heard on pressure consonants < 3 examples on different sounds
2	Frequently heard on pressure consonants ≥ 3 examples on different sounds

8

4b Nasal Turbulence

Rating	Description
0	Absent on pressure consonants
1	Occasionally heard on pressure consonants < 3 examples on different sounds
2	Frequently heard on pressure consonants ≥ 3 examples on different sounds

8

Figure 5-3 Scale points used in the CAPS-A framework to measure resonance

5.5.2 Results

I. Transcription agreement

Table 5-6 Degree of transcription agreement

Degree of agreement	***n***	**%**
Little disagreement	1	0.7
Partial agreement	14	9.3
Little agreement	27	18.0
Complete agreement	108	72.0
Total	**150**	

Table 5-6 presents the percentage of agreement for different levels of transcription. As shown in the table, the total number of consonants transcribed was 150. For segmental transcriptions, 72.0% complete agreement was achieved which, is above the threshold of 70% recommended by Shriberg *et al*. (2010), as an acceptable level of transcription agreement.

II. Resonance and airflow ratings agreement

Table 5-7 Agreement between the two transcribers for Child 1

Child 1	Transcriber 1	Transcriber 2	(%) of agreement
Hypernasality	2	2	100
Hyponasality	1	1	100
Nasal emission	0	0	100
Nasal turbulence	0	0	100

Table 5-8 Agreement between the two transcribers for Child 2

Child 2	Transcriber 1	Transcriber 2	(%) of agreement
Hypernasality	1	1	100
Hyponasality	0	0	100
Nasal emission	0	0	100
Nasal turbulence	2	2	100

As the reliability assessment was conducted for only two children, a KAPPA test could not be conducted. Instead, the ratings of the two transcribers were compared for each variable, including hypernasality, hyponasality, nasal emission and nasal turbulence (See Table 5-7 and Table 5-8). As shown from the tables, ratings for the two transcribers achieved 100.0% agreement for each of the variables tested: hypernasality, hyponasality, nasal emission and nasal turbulence.

5.4.3 Summary

This chapter provided a description of the main aim of the study, research questions as well as design and methods employed in this study. This is followed by a discussion of the protocol used for assessing reliability of transcriptions and perceptual ratings. The results of reliability exercise are all presented which suggested that the level of transcription's agreement has met the basic standard set in the literature. This also applies to the results of airflow and resonance reported here.

So far, along with the current chapter (Chapter 5), Chapters 1 to 4 provided appraisal and key points of the literature on phonetics and phonology and their development in Arabic and English. Impacts of cleft on speech output were also reviewed along with different approaches for assessing speech output related to cleft palate.

For the current study, a speech assessment protocol for Arabic-speaking children was designed based on the Great Ormond Street Speech Assessment protocol (GOS.SP.ASS'98, Sell *et al.*, 1999). This Arabic version of GOS.SP.ASS is one of the substantial contributions of the current study. The next chapter describes the structure of the protocol and its content. The chapter also describes the challenges encountered while devising the protocol.

Chapter 6 **Developing the Speech Assessment Tool**

6.1 Introduction

It has been claimed that speech is one of the most important outcomes of palatal surgery (together with facial growth) (Sell *et al*., 1994). It is crucial for speech and language therapists to obtain as much information as possible about abnormal speech characteristics related to cleft palate so that a proper treatment plan could be conducted accordingly. There are some suggestions for the need of a universal, cross-linguistic tool in the management of cleft lip and palate. This is recommended in order to draw comparisons between individual patients as well as to collect as much information about changes in speech production (Paal *et al*., 2005). Alternatively, it can be suggested that rather than having a universal tool, it is more useful to devise a language and/or a cultural-specific speech assessment tool, for the reasons described later in this chapter.

The main aim of this chapter is to discuss issues related to devising an assessment tool for Arabic speakers with cleft palate. Prior to description of the assessment tool, the chapter will consider different methods and protocols used for assessing speech in individuals with cleft palate. Afterwards, the reasons will be given for choosing GOS.SP.ASS'98 as a foundation for devising the Arabic version of GOS.SP.ASS. Subsequently, information will be presented regarding the speech parameters included in the material and finally description of the issues encountered while constructing the assessment tool.

6.2 Speech assessment protocols

There are several systems for measuring the outcome for speech in English-speaking individuals with cleft palate (e.g. Sell *et al*., 1994; Harding *et al*., 1997; Eurocleft Speech Group, 2000; John *et al*., 2006) as well as assessments for other languages, including German GOS.SP.ASS (Bressmann *et al*., 2002) and Amharic GOS.SP.ASS (Mekonnen, 2013), SVANTE (Lohmander *et al*., 2005) and SISL (Breuls *et al*., 2005). However, it is difficult to use assessments based around a specific language for the purpose of cross-linguistic comparisons, as there is a considerable variation among different languages in terms of sound systems and structure. There are also great differences between the various systems currently being used to collect and analyse perceptual data of speech. In this regard, Lohmander and Olsson (2004: p.65) stated, *"there is a lack of reported information and large differences in ways of collecting and analysing data concerning perceptual assessment of speech in patients with cleft palate"*.

Prior to the development of the GOS.SP.ASS, McComb (1989) suggested the necessity of developing a standardised speech assessment on a national and, if possible, international basis, so that comparisons between centres can be made. A standardised tool can enhance the validity of intra and inter-subject comparisons. Shaw (2004) claimed that one of the advantages of such a universal system would be using it as a clinical trial for rating and reporting perceptual speech samples of different countries and regions. More recently, Henningsson *et al*. (2009) proposed a system that uses salient parameters for reporting speech samples regardless of the language spoken by the individual. The parameters include hypernasality, hyponasality, audible nasal air emission and/or nasal turbulence, sound production errors and voice disorder.

In some countries, however, including Middle Eastern countries, there is still not an available standardised assessment for cleft palate speech. Hence, speech errors are assessed using informal articulation assessment tests developed by therapists in individual speech clinics or hospitals, while nasality is assessed perceptually or instrumentally (with the use of a Nasometer), but still not using assessment material which is common to all clinics and hospitals. Undoubtedly, there is a need for a standardised assessment that can be applicable at least to some of the Arabic-speaking countries. This is important so that, for example, assessment of speech for the purpose of treatment outcome and research could be made and compared between centres after surgical correction. Furthermore, each language has its own phonetic inventories and phonological system, and in the case of Arabic, the language contains emphatic, uvular and pharyngeal consonants so that developing a language-specific standardised assessment would enable the effect of these sounds on cleft palate speech to be explored.

6.3 Why GOS.SP.ASS?

As reported earlier, there are several systems for assessing speech characteristics for individuals with cleft palate. GOS.SP.ASS'98 has been chosen as a base for the development of an assessment tool in the current study for several reasons, including:

- First, it is considered to be a comprehensive speech assessment protocol for speech disorders associated with cleft palate and/or velopharyngeal dysfunction (Sell *et al*., 1999).
- Second, GOS.SP.ASS enables the examiner to identify the aetiological factors and to plan for further management.
- Third, it provides detailed information for research and clinical purposes and can be used to measure reliability (Sell *et al*., 1999; John *et al*., 2006).
- Fourth, GOS.SP.ASS permits the assessment of different speech parameters including resonance, articulation and voice quality. It also includes sections for oral examination and description of visual appearance of speech.
- Fifth, as reported in Chapter 4, GOS.SP.ASS has been translated to other languages such as German (Bressmann *et al*., 2002) and Amharic (Mekonnen, 2013).

6.4 The structure of Saudi Arabian GOS.SP.ASS

The Arabic version of GOS.SP.ASS (see Appendix 3) has been designed based on the original GOS.SP.ASS'98. The Arabic version has a similar structure and subsections and also includes some adaptations that were considered to be essential when designing the Saudi Arabic version of GOS.SP.ASS. The stimuli used in the Arabic version of GOS.SP.ASS includea list of 83 single words and 28 sentences, for elicitation an repetition respectively, designed to elicit the consonants of Arabic in different word positions

6.4.1 Resonance and nasal airflow

The first section includes evaluation of nasal resonance and airflow. As reported in Chapter 3, resonance refers to the distribution of sound in the nasal cavity, whereas airflow refers to the amount of air needed to produce speech sounds. Three parameters are included in resonance: hypernasality, hyponasality and mixed nasal resonance. The parameters included in the nasal airflow are nasal emission, nasal turbulence and grimace. In the Arabic version of GOS.SP.ASS, all parameters are similar to the original GOS.SP.ASS which will be described in the section below.

I. Hypernasality

Hypernasality is mostly perceived on vowels and approximants. It is rated on a four-point scale depending on the level of severity. Grade 0 indicates normal tone; Grade 1 indicates hypernasality perceived on vowels and approximants [ɑ̃,ũ,ɔ̃] [w̃,ɹ̃,l̃,ɭ̃, j̃]; Grade 2 indicates hypernasality perceived not only on vowels and approximants but also includes weakened consonants along with nasalisation of voiced consonants [b̃, d̃, z̃]. Grade 3 includes all of the above features, with in addition the replacement of oral targets by nasal consonants (i.e. /b/→[m], /d/→[n]). All of the four-point rating scale is available in the Arabic version of GOS.SP.ASS. Furthermore, as with the original GOS.SP.ASS'98, options for recording hypernasality as consistent or inconsistent are also available.

II. Hyponasality

In the original GOS.SP.ASS'98, hyponasality is judged on production of nasal consonants, using a three-point scale to account for degrees of severity. Grade 0 indicates normal tone; Grade 1 indicates a moderate hyponasality perceived on nasal consonants; Grade 2 indicates the replacement of nasal consonants with plosives (e.g. /n/ →[d], /m/ →[b]).

In the Arabic version of GOS.SP.ASS, a binary system was used were only two categories were included, *absent* in case of normal tone; *present* in case of a moderate hyponasality perceived on nasal consonants (e.g. /m/→[m̃]). Switching from a 3-point scale to a binary system in Arabic version of GOS.SP.ASS was chosen based on the suggestion of John *et al*. (2006) where they reported an increased reliability of hyponasality when the scale was reduced in such a way.

III. Cul-de-sac and mixed resonance

The categories used in the Arabic version of GOS.SP.ASS (i.e. present or absent) are the same as the original test and are appropriate to be used without modification.

IV. Nasal emission and nasal turbulence

Nasal emission and nasal turbulence are also included in the Arabic version, where they may accompany and/or replace consonants. Nasal emission is classified as audible or inaudible. Inaudible emission cannot be perceived by the listener, however to detect it, GOS.SP.ASS provides a mirror test to detect inaudible nasal emission. The test is conducted by placing the mirror under the nostrils during the production of high pressure consonants (i.e. stops, fricatives and affricates). If misting is revealed on the mirror, then audible nasal emission is present.

In the English GOS.SP.ASS'98, all of the mentioned parameters (i.e. audible nasal emission, inaudible nasal emission and nasal turbulence) are perceptually assessed using a three-point scale for the presence of a characteristic, where Grade 0 indicates an absent nasal emission and/or turbulence; Grade 1 indicates slight nasal emission and/or turbulence; Grade 2 indicates marked nasal emission and/or turbulence to the degree of replacing consonants with nasal fricatives.

In the Arabic version of GOS.SP.ASS, only two-point scales were used: *absent* in case of zero nasal emission and/or turbulence; *present* in case of nasal emission and/or turbulence accompanying the production of consonants. Nasal emission and/or turbulence replacing consonants (i.e. Grade 2) has been removed from the nasal airflow assessment and included under the cleft speech characteristics (CSC) (i.e. active nasal fricatives and velopharyngeal fricatives). Similar to the English GOS.SP.ASS'98, consistency (i.e. consistent and/or inconsistent) is also evaluated and included in the Arabic GOS.SP.ASS.

V. Grimace

Nasal grimace reflects a subconscious attempt by the speaker with cleft palate to inhibit abnormal nasal flow by restricting the nares and sometimes other facial muscles (Sell *et al.*, 1994) and thus can be seen as a compensatory behaviour. Thus, it is considered as a speech-related behaviour that may not only be visually distracting to the listener but might also give a visual clue to the possible dysfunction of the velopharyngeal port. Such behaviour may indicate velopharyngeal dysfunction. In the English GOS.SP.ASS, a 4-point scale was used for rating grimace. In the Arabic version of GOS.SP.ASS, a 2-point scale was used (i.e. present and absent) as John *et al*. (2006) reported an improved reliability of grimace ratings when reducing the 4-point scale to a 2-point scale.

6.4.2 Consonant production

In the English GOS.SP.ASS, the consonant production section is used to document production of consonants. It involves the realisations of syllable initial and syllable final targets which should be phonetically transcribed so that the child's production can be compared over time. In the Saudi Arabian GOS.SP.ASS, the consonant production section is used to document the individual's consonant realisations in word initial position, word-medial position and word-final position.

In contrast to the English GOS.SP.ASS, the Arabic version has a different consonant inventory, with the addition of more sounds and sound classes such as pharyngeal consonants (/ħ, ʕ/), uvulars (/χ, ʁ, q/) and emphatics (/sˤ, dˤ, tˤ , ðˤ/).

6.4.3 Cleft speech characteristics (CSCs)

The consonant realisations are classified into cleft speech characteristics according to the nature of the error. Characteristics have been categorised into two forms: active characteristics, which consist of realisations that have been actively produced as an alternative to target consonants; and passive characteristics, which consist of realisations that are the passive consequence of velopharyngeal incompetence or fistulae affecting the achievement of intraoral pressure (Harding and Grunwell, 1996).

Active cleft speech characteristics involve misarticulations affecting the tongue tip and tongue blade sounds; lateralisation and lateral articulation, palatalisation and palatal articulation, double articulation, backing and active nasal fricatives. Passive characteristics include weak/nasalised consonants, nasal realisation of pressure consonants, absent pressure consonants and gliding of fricatives/affricates. A detailed discussion of each characteristic is given in Sell *et al*. (1999).

In the coming sections, cleft speech characteristics (CSCs) which are included in the Arabic version assessment material will be described.

6.4.3.1 Active cleft speech characteristics

I. Anterior oral CSCs

a) Misarticulations involving the tongue tip/blade sounds

This category includes dentalisation, non-cleft dentalisation and linguolabial articulation. Dentalisation has been reported frequently by clinicians in patients with cleft palate and it occurs when the tip of the tongue makes a contact with the back of the upper front teeth (e.g. [t̪]). Interdental articulation, which is considered as a normal immaturity, is defined as a production of a target alveolar sound with the placement of the tongue tip between the upper and lower front teeth (e.g. /s/ → [θ]). Linguolabial articulation occurs by placing the tongue tip or blade between the upper and lower lips (e.g. [d̼]).

b) Lateralisation/lateral articulation

This type of articulation occurs when the tongue obstructs the central region of the oral cavity and thus the airstream is directed to one or both sides (e.g. /s/, /ʃ/ → [ɬ]).

c) Palatalisation/palatal articulation

Sell *et al.* (1999) have made a distinction between palatalisation and palatal articulation. Palatalisation involves a secondary articulation (e.g. [dʲ]), whereas palatal articulation involves a dorsal modification of alveolar targets e.g. /s, z/→ [ç, ʑ]. In this case, the child is using the dorsum of the tongue instead of the tip or the blade with the posterior border of the hard palate (Okazaki *et al*., 1980, 1991; Michi *et al*., 1986).

d) Double articulation

Double articulation involves a simultaneous production of two consonants of the same degree of stricture (Ladefoged and Maddieson, 1996). It usually affects the alveolar stop targets (e.g. /t, d/→[t͡k] , [d͡g]).

II. Posterior CSCs

a) Backing

There are two main types of backing, namely backing within the oral cavity and backing of oral targets to post-uvular place of articulation (Henningsson, *et al*., 2009).

- *Backing within the oral cavity:* Dental and alveolar pressure consonants (obstruents) are retracted to palatal [c, ɟ, ç, ʝ], velar [k, g, x, ɣ] or uvular [q, ɢ, χ, ʁ] place of articulation.

- *Backing of oral targets to post-uvular place of articulation:* Pressure consonants (obstruents) are retracted to pharyngeal [ʡ,ʕ, ħ] or glottal place [ʔ, h] of articulation.

b) Active nasal fricatives

When nasal emission or nasal turbulence replaces a target fricative or affricate (e.g./s/→ [ñ̥] and/or [n̥̈]), it is classified as a active nasal fricative (Harding and Grunwell, 1998).

c) Velopharyngeal fricative

This speech behaviour involves nasal emission and/or turbulence replacing target plosives and/or affricate.

6.4.3.2 Passive cleft speech characteristics

Passive cleft speech characteristics occur when no effort is made to compensate for the effect of the structural abnormality i.e. the cleft palate. It includes weak or nasalised consonants, nasal realisation of pressure consonants, absent pressure consonants and gliding of fricatives and affricates.

a) Nasalised/weak consonants

This category provides an indication of reduced intraoral pressure so that, as a consequence, there is weak oral pressure (e.g. [b̹, d̹]) as well as a perception of nasalised oral consonants (e.g. [d̃, z̃]).

b) Nasal realisation of plosives, fricatives and/or affricate

Nasal realisation of pressure consonants is a classic cleft type feature which is commonly reported in the literature. In this type, when producing the consonant the manner of articulation is not maintained because the airstream is passively directed nasally instead of orally e.g. /b,s/ may be realised as [m,, n]. Stengelhofen (1989) suggested that nasal realisation of plosives is usually associated with lack of intraoral pressure, which is usually the result of VPI (Paliobei *et al*., 2005; Sell *et al*., 2009).

c) Absent pressure consonants

This speech pattern involves the lack of any of the pressure consonants, thus speech involves only nasals, glides and approximants.

d) Gliding of fricatives and/or affricates

This speech pattern involves gliding of fricatives and/or affricates, so that /s, ʃ, dʒ/ realised as [j,w]. Gliding has been considered by Harding and Grunwell (1998) as an active process, whereas Sell *et al*. (1999) suggested that it might occur as a developmental process which is extended as a result of cleft palate.

6.4.4 Other sections

6.4.4.1 Developmental errors

This category includes information about any developmental problems e.g. fronting, stopping, lateralisation of /r/, and de-emphasis. Recording a history of developmental errors is important as it can give an indication of coexisting phonological disorders. It may also affect the child's ability to compensate for a structural defect e.g. cleft palate. Furthermore, it is essential to include examples of developmental problems e.g. language difficulties (Grunwell and Harding, 1995) because the priority of speech therapy may differ accordingly.

Depending on the above findings, conclusions can be drawn and recorded at the bottom of the forms in terms of the form therapy should take, and suggestions for further management. Relevant information provided by the parent can also be noted.

6.4.4.2 Transcription

This section of the GOS.SP.ASS can include a whole-word transcription of a speech sample which can provide the user with further useful information that is not evident in a target response production. It can also include a transcription of unusual vowel production, idiosyncratic consonant production, the use of preferred consonant even with the availability of other consonants, and consonant harmony.

6.4.4.3 Voice

Individuals with cleft palate or VPI are at risk for phonatory disorders such as hoarseness, breathiness, strangled or strained voice quality, abnormal pitch and low speaking volume (Sell *et al*., 1994, 1999). These problems are assumed to occur as compensatory strategies secondary to velopharyngeal dysfunction, whereby phonatory abnormalities arise as a consequence of the speaker's attempts to control or disguise inappropriate nasal resonance or airflow. GOS.SP.ASS'98 uses the 'voice' section to report these problems under three given categories (i.e. normal, dysphonic, reduced volume). In the Arabic GOS.SP.ASS, a binary rating was used: '0' for a 'normal voice and '1' for a 'voice disorder' (Henningsson *et al*., 2009). Limited binary rating has been chosen for the Arabic GOS.SP.ASS based on John *et al*.'s (2006) study where they reported that intra-reliability increased with a binary system of *present* vs. *absent.*

6.4.4.4 Visual appearance of speech

The section captures any visual appearance of speech organs including, in particular, tongue protrusion, shortened upper lip and asymmetrical facial appearance.

6.4.4.5 Oral examination

The GOS.SP.ASS assessment test, in both English and Arabic versions, includes a complete oro-facial examination, which is helpful in contributing toward an overall diagnosis and management plan.

6.4.4.6 Language

As delayed language development could be associated with cleft palate, distinction should be made between this delay and delayed language development unrelated to cleft. Furthermore, specific language disorders could be documented in this section.

6.4.4.7 Identifiable aetiology

The last section involves identifying possible aetiological factors that might contribute to the presence of speech disorders. For example, many syndromes could possibly be associated with cleft speech disorder e.g. velocardiofacial syndrome arising from 22q11 microdeletion (Shprintzen *et al*., 1978, 2008) which involves VPI as well as cardiac problems.

6.4.4.8 Intervention plan

Management plans and future recommendation are written in this section.

6.4.4.9 Areas requiring further assessment

Issues which need further investigation are included in this section. This includes, for example, referring the patient to ENT or orthodontics. Further instrumental assessments are also included in this section e.g. nasoendoscopy, videofluoroscopy.

6.4.4.10 Additional notes

Any additional comments can be included in this section e.g. child and/or parent attitude, recommendations and advices given by the speech and language therapists.

6.5 Words and Sentences for Speech Elicitation (Construction and Challenges)

The following sub-section deals specifically with the challenges of adapting the GOS.SP.ASS for Arabic.

For any speech assessment tool, there is a need for a speech sample that effectively assesses the consistency and frequency of errors (LeBlanc and Shprintzen, 1996) and that is representative and balanced (Brøndsted *et al.*, 1994). Consonants produced in isolation are commonly considered insufficient for speech assessment, thus the sound should be integrated within the word. As a result, the test should generally involve evaluation of different parameters either in controlled speech (i.e. repetition), spontaneous speech (i.e. picture naming) or a natural framework (i.e. conversational speech).

In Arabic, there are eight plosives /b, t, d, dˤ, tˤ, q, k, ʔ/, two nasals /m, n/, two approximants /w,j/, one lateral /l/, one trill /r/, one affricate /dʒ/ and 13 fricatives /θ, ħ, χ, ð, r, s, ʃ, sˤ, ðˤ, ʕ, ʁ, f, h/. Words and sentences were designed for each consonant in the Arabic language, the sentences containing the target sounds in word-initial, -medial and -final positions.

It is important to follow specific principles while constructing the speech sample. Sell *et al.* (1999) suggested some guidelines to consider when developing sentences. They pointed out that sentences need to be “imageable, meaningful, and relevant whilst essentially containing maximal numbers of each target consonant" (Sell *et al.*, 1999; 34). It is also essential to remain aware that other vulnerable sounds (e.g. stops other than the target sound in a sentence) should not be included if at all possible as this might interfere with production or perception of other consonants. Further recommendations have also been made for the selection of single words and the construction of sentences, including those by Hutters and Henningsson, 2004; Henningsson *et al.*, 2009; and the Eurocran Speech Project, 2008 (http://www.eurocran.org, recently moved to http://clispi.org). In terms of single words, some of the recommendations are similar to Sell's guidelines in which they stressed the importance of including only one target pressure consonant per word. It is also essential not to include nasal sounds (Henningsson and Willadsen, 2011). Similar suggestions are also given while constructing sentences: sentences should include the target sound in all word positions (i.e. initial, medial and final) but only one pressure sound should be included within an individual word in a sentence.

In practice, an attempt was made to follow all of the above suggested guidelines when constructing the speech sample for the Saudi Arabian GOS.SP.ASS. However, a number of challenges arose, particularly in terms of phonological constraints in dialectal Arabic. For instance, some of the sounds have limited distributions and only occur in specific word positions; for example the sounds /ðˤ, ð, w, j/, do not occur frequently in word-final position. In fact, /w and /j/ can occur word finally in MSA but not in Saudi Arabic.

Additional challenges were found in the differences arising from dialectal variations. This occurs as a result of socio-linguistic differences where variation in the production of some sounds and words might occur (e.g. /θ/ →/s/, /dˤ/→/ðˤ/, /q/→/g/). Although the scoring of dialectal variants were not mentioned in GOS.SP.ASS'98, a child who use a dialectal variant accurately would still be scored as correct in the current study, as this would be correct for their dialect.

It was particularly challenging, given the structure of words in Arabic as well as grammatical considerations, not to include other vulnerable sounds along with the target sound especially while constructing the sentences. An attempt was made to follow the guidelines but due to the phonotactic features of Arabic, the problem could not always be avoided. An issue also arises related to the frequency of familiar words containing specific target sounds (e.g. /ðˤ/, /ð/, /w/, /j/). For example, glides and /j/ are usually realised as a vowel in word-final position e.g. /ʃʊr.tˤij/ (policeman) →[ʃʊr.tˤi]. If the Saudi Arabian GOS.SP.ASS is to be widely adopted, the words used in the sentences need to be recognised by speakers of the different dialects of Arabic particularly different dialects in Saudi Arabia.

In order to have comparable and controlled data samples, the sentences are elicited, as with the UK GOS.SP.ASS, by the procedure of repetition. As Sell *et al*. (1999) argue, sentence repetition is a useful and economical method for collecting data. A full set of colour pictures can be used to facilitate sentence repetition. In addition to sentence repetition, single words were elicited spontaneously by picture naming (see section 5.4.1). Most of the stimulus words are considered familiar and commonly used in the children's environment, and are presented as well through colourful picture. The suitability of stimulus words and sentences was tested through a pilot study (see sections 5.4.1 and 5.4.2).

To elicit the target word in single word assessment, the examiner needs to instruct the child to look at the pictures and to name the object, or answer cue questions about them. The target words have been carefully chosen to be familiar (familiarity of the tested words was tested through a pilot study: see sections 5.4.1 and 5.4.2), and chosen because they are produced similarly across different dialects of Arabic and different regions in Saudi Arabia. In addition, they are also imageable and meaningful. However, it could be anticipated that even if a word meets most of the criteria, it might still be difficult for an individual child to recognise. If the target word is unfamiliar to the child, the examiner would use repetition to elicit the target word, and it is assumed that such a problem could also be decreased through the provision of pictures for each word.

6.6 Summary

The current chapter provided an overview of issues related to developing an assessment tool for Arabic speakers with cleft palate. The chapter started with methods and protocols used in assessing speech in individuals with cleft palate. Then an explanation was given for the rationale of choosing GOS.SP.ASS as a foundation for devising the current assessment protocol for Arabic-speakers.

Furthermore, the speech categories and parameters included in the protocol were defined and described. Some changes were made to the original GOS.SP.ASS which was also described. Guidelines were suggested by Sell *et al*. (1999) to consider while constructing the sentences. However, challenges have been encountered while designing the Arabic sentences and also the single words; all of these challenges were described in this chapter. The coming chapters (7, 8 and 9) will describe the results of the current study.

Chapter 7 Main Study Results 1: Phonetic and Phonological Analysis

7.1 Introduction

It is already known that individuals with cleft palate usually present with certain atypical speech behaviours that can be recognised perceptually by experienced SLPs who are familiar with cleft palate speech assessment (Sell, 2005). With respect to assessment, there are different protocols designed specifically to assess cleft palate speech errors. For this section, an Arabic version of the Great Ormond Street Speech Assessment (GOS.SP.ASS; Sell *et al.*, 1994, 1999) was designed and used to evaluate cleft palate speech features for participants speaking Arabic.

From 21 participants, speech samples were elicited in two different contexts, that is, picture- naming and sentence repetitions. Transcriptions were made using symbols from the IPA (1993, revised 1996), ExtIPA (Ball *et al.*, 1996) and VoQS: Voice Quality Symbols (Ball *et al.*, 1995). The GOS.SP.ASS form was used to plot the realisations for the target consonants in word-initial, word-medial[8] and word-final positions. From the data, different speech features were categorised, summarised and tabulated.

The results of this study will be presented in two sections: The first section (phonetic analysis) describes the perceptual analysis of cleft palate speech. In this section, two main questions will be addressed:

1. What are the speech development patterns found in typically developing children and children with cleft palate in Arabic?

[8] A consonant which is situated in the middle of the word

2. What are the cleft speech characteristics found in the speech of the Arabic children with cleft palate and how they are related to findings in other languages?

7.2 Cleft speech features and phonetic analysis

In the first section, group results are presented for each of the individual GOS.SP.ASS cleft speech features[9] together with some illustrative words given as examples from individual children. The GOS.SP.ASS cleft palate speech features include resonance and nasal air flow, cleft speech characteristics (CSCs), and finally other cleft speech errors.

It is important to note at the outset that intra-speaker variability is found throughout the data. For example, a participant may produce a particular target consonant correctly in one position (e.g. word-initial) but not in medial or final positions. This will be clarified in the coming examples and more details will be provided in the case studies that will be presented in Chapter 7.

7.3 Resonance

In this section, characteristics of resonance found in the data are presented (See Table 7-1). Using perceptual analysis of words and sentences, the figure of hypernasality was obtained when the children had Grade 1 and Grade 2 hypernasality, whereas the figure of hyponasality was obtained when the children had Grade 1 hyponasality.

[9]As reported in the methodology chapter, GOS.SP.ASS involves two sections: single words and sentences (i.e. GOS.SP.ASS words list involves whole word transcription, whereas GOS.SP.ASS sentences involve segmental transcription rather than whole word transcription).

Table 7-1 Number of children presenting with hypernasality and hyponasality

Resonance	Number of children (*n*=21)
Hypernasality	11
Hyponasality	3

7.3.1 Hypernasality

To detect hypernasality, in particular, and other speech problems related to cleft palate, whole word transcription was carried out for children's single word productions. Whole word transcription is important because, as already reported in Chapter 5, hypernasality is mainly perceived on vowels and approximants (e.g. [ɑ̃, ʉ̃, ɔ̃] [w̃, ɹ̃, l̃, ɭ̃, j̃]). In more severe cases, hypernasality is not only perceived on vowels (e.g.[ɑ̃, ʉ̃, ɔ̃]) and approximants [w̃, ɹ̃, l̃, ɭ̃, j̃], but it also affects voiced obstruents as well as approximants, which, as described by GOS.SP.ASS'98, become nasalised and weakly produced: thus, [b̃, d̃, z̃][10].The most severe manifestation of nasality is when voiced plosives are replaced by nasal equivalents /b d g/→[m n ŋ].

Following the Arabic version of GOS.SP.ASS, the last two types of nasality (i.e. weak/nasalised plosives and nasal replacement of plosives) have been considered as cleft palate speech characteristics and therefore a section for each will be covered in this chapter under cleft speech characteristics (CSC). However, in this section the focus will be restricted to nasality which affected vowels.

[10]N.B. the phonetic transcription of a nasalised plosive is not straightforward and it has been questioned whether plosives can ever be nasalised (ICPLA ,2010)

On the basis of perceptual judgments, eleven children display inconsistent hypernasality that is readily perceived on vowels such as [ɑ̃, ʊ̃, ɔ̃, æ̃, ã, õ, ɪ̃, ɛ̃].This appears in the following examples taken from the children:

- Child Sa's single word production of /χaruːf/ as [χãwuːf̪] (GOS.SP.ASS words).
- Child Nah's single word production of /mʊθal.laθ/ as [mʊθãl.lãθ] (GOS.SP.ASS words).
- Child Mon's single word production of /ʔar.nab/ as [ʔa(r[11])nãb] (GOS.SP.ASS words).
- Child Sau's single word production of /war.dah/ as [wan.n̪ãh] (GOS.SP.ASS words).

7.3.2 Hyponasality

Dalston *et al*. (1991) define hyponasality as a reduced amount of realisation of nasal resonance in nasal consonants, such as /m n/. Thus, a moderate hyponasality is when nasal consonants are slightly denasal /m n ŋ/→ [m̃ ñ ŋ̃] and in more severe cases, nasal consonants realised as plosives /m n ŋ/→ [b, d, g]. Only three children present with moderate hyponasality (Ma, Mu, Sa).

The following examples are taken from their speech:

- Child Mu's production of [ʔañ.ñab] for the target word /ʔar.nab/ (GOS.SP.ASS words).
- Child Ma's denasal realisation of /m/ in the target word /jaħ.mɪl/→[jaħ.m̃ɪl] (GOS.SP.ASS sentences)..
- Child Sa's denasal realisation of /n/ in the target word /əlqʊrʔaːn/→[əlqʊrʔaːñ] (GOS.SP.ASS sentences).

[11]Consonants between brackets signify silent articulation.

7.4 Nasal airflow

In this section, characteristics of nasal airflow found in the data are presented.

Table 7-2 Number of children presenting with audible nasal air emission and nasal turbulence

Resonance	Number of children (*n*=21)
Audible nasal air emission	4
Nasal turbulence	12

7.4.1 Audible Nasal Air Emission

Nasal emission may occur for different reasons. One is the occurrence of velopharyngeal dysfunction where the child makes no effort to compensate for the inadequacy, and a second possibility is the presence of nasal fistulae. Four children exhibit audible nasal emission accompanying the production of plosives, affricate and, most commonly, fricatives.

Table 7-3 Children presenting with audible nasal air emission

Child Initial	Palatal articulation	
Da	/t/→[t͌]	WI
	/tˤ/→[tˤ͌]	WM
Me	/f/→[f͌]	WI
	/s/→[θ͌]	WI WM WF
	/ʃ /→[θ͌]	WI WF
	/ʃ /→[s͌]	WM
	/sˤ/→[θ͌]	WI WM WF
	/f/→[f͌]	WI WM WF
	/t/→[t͌]	WI
	/s/→[θ͌]	WI WM WF
	/ʃ /→[θ͌]	WM WF
	/sˤ/→[θ͌]	WI WM WF
	/dˤ/ → [ð͌]	WI
Moh	/s/→[s͌]	WF

	/sˤ/→[sˤ͊]	WI
	/ʤ/→[d͊]	WI
Mon	/t/→[tˤ͊]	WI
	/t/→[t͊]	WM
	/θ/→[p͊]	WI
	/t/→[t͊]	WM

***In tables presented throughout this chapter:**
Rows in white = single words production
Rows shaded with grey = sentence repetition
WI= word- initial, WM =word-medial, WF=word-final

7.4.2 Nasal Turbulence

Nasal turbulence is considered as a severe form of nasal emission, generally regarded as a consequence of turbulent airstream located in the velopharyngeal valve. It was detected in the speech of twelve children accompanying stops, fricatives and affricate (see Table 7-4). In severe cases, nasal turbulence may replace consonants and in such cases, these are referred to as active nasal fricatives (in case of fricatives) or velopharyngeal fricative (in case of affricate and stop consonants): such cases will be discussed in section 7.5.1.8 (i.e. Posterior CSCs).

Table 7-4 Children presenting with nasal turbulence

Child Initial	Nasal turbulence	
AG	/t/→ [t͊]	WF
	/f/→ [f͊]	WF
	/d/→ [d͊]	WI
	/θ/→[θ͊]	WI
	/s/→[s͊]	WF
	/sˤ/ →[θ͊]	WM
	/sˤ/ → [sˤ͊]	WF
	/dˤ/→[d͊]	WI
	/tˤ/→[tˤ͊]	WI WF
Da	/ðˤ/→[ðˤ͊]	WI WM WF
Gh	/t/→ [t͊]	WF

	/d/→ [d̃]	WM
	/ð/→ [ð̃]	WM
	/s/→[s̃]	WM WF
	/z/→ [z̃]	WM
	/sˤ/ → [sˤ̃]	WI
	/sˤ/ → [θ̃]	WF
	/tˤ/→[tˤ̃]	WM
	/t/ → [t̃]	WM
	/d/→ [d̃]	WM
	/z/→ [z̃]	WF
	/ʤ/→[ʤ̃]	WI WM WF
Jo	/dˤ/→[dˤ̃]	WI
	/tˤ/→[tˤ̃]	WM WF
	/k/→[k̃]	WI WM WF
	/d/→ [d̃]	WI
Ju	/b/→[b̃]	WM
Ma	/k/→[k̃]	WI
	/t/ → [t̃]	WM
Mis	/tˤ/→[tˤ̃]	WI
	/f/→ [f̃]	WI
	/t/ → [t̃]	WF
	/s/→[θ ̃]	WF
	/k/→[k̃]	WM WF
	/χ/→[χ̃]	WI
	/t/ → [t ̃]	WI
	/s/→[θ ̃]	WI WF
	/sˤ/ → [sˤ̃]	WM WF
	/dˤ/→[dˤ̃]	WI
	/ðˤ/→[dˤ̃]	WI
Mu	/k/→[k̃]	WI WM
	/s/→[θ̃]	WI WM WF
	/z/→ [ð̃]	WI WM WF
	/ʃ/→ [θ̃]	WI WM
	/ð/→ [ð̃]	WF
	/θ/→ [θ̃]	WF
	/sˤ/→[θ̃]	WI WM WF
	/ʁ/→ [ʁ̃]	WM
	/θ/→ [t ̃]	WM
	/z/→ [ð ̃]	WM WF
Nah	/ʃ/→ [θ ̃]	WM WF

	/sˤ/→[θ͌]	WI WF
	/sˤ/→[θ͌]	WM
	/θ/→ [θ͌]	WF
	/t/ → [t͌]	WM
	/d /→[d͌]	WI
	/ʤ/→[d͌]	WF
	/dˤ/→[dˤ͌]	WM
	/s/→[s͌]	WM
	/z/→[d͌]	WI
	/ʤ/→[d͌]	WI
Os	/sˤ/ → [sˤ͌]	WM WF
	/s/→[s̪͌]	WF
	/θ/→ [θ͌]	WI
	/b/→ [b ͌]	WI
Re	/s/→[s͌]	WI WM WF
	/dˤ/→[ðˤ͌]	WI
	/s/→[θ͌]	WF
	/ʃ/→ [ʃ ͌]	WM
	/ʃ/→ [θ͌]	WF
	/ʤ/→[d͌g]	WM
	/sˤ/→[θ͌]	WI WM
	/ðˤ/→ [ð̞͌]	WM
	/ʁ/→ [ʁ͌]	WM
	/θ/→ [θ ͌]	WM WF
	/ʃ/→ [θ ͌]	WM WF
	/ʤ /→ [ð̞͌]	WI
Sh	/ʤ /→ [d̞͌g]	WM WF
	/tˤ/→ [tˤ͌]	WI
	/tˤ/→ [q͌]	WM
	/ʁ/→ [ʁ͌]	WI WM
	/ħ/ →[ħ͌]	WI

7.5 Cleft Speech Characteristics (CSCs)

Characteristics have been grouped into active characteristics, which correspond to realisations that have been actively produced as an alternative to target consonants, and passive characteristics of speech that are the passive consequences of velopharyngeal incompetence or fistulae affecting the achievement of intraoral pressure (Harding and Grunwell, 1996).

Based on phonetic transcription, many cleft palate speech characteristics can be identified in the speech data. These are discussed, in accordance with the Arabic version of GOS.SP.ASS form, where speech characteristics are grouped as follows:

- Active cleft speech characteristics include: misarticulations affecting the tongue tip/blade, lateralisation/lateral articulation, palatalisation/ palatal articulation, double articulation, backing and active nasal fricatives.

- Passive characteristics include weak/nasalised consonants, nasal realisation of pressure consonants, absent pressure consonants and gliding of fricatives/affricates.

- Additional cleft speech characteristics: ejectives, linguolabial articulation and strong articulation.

In the coming sections, cleft speech characteristics (CSC) which are included in the Arabic version assessment material will be described.
Active, passive and other characteristics found in the participants' speech production are listed in Table 7-5.

Table 7-5 Summary of cleft speech characteristics found in the study

CSCs	**Number of participants affected (*n* = 21)**
Dental realisation related to cleft palate	**5**
Linguolabial articulation	**2**
Lateralisation/lateral articulation	**8**
Palatalisation/palatal articulation	**2**
Double articulation	**2**
Backing to velar	**4**

Backing to uvular	**4**
Pharyngeal articulation	**0**
Glottal articulation	**9**
Active nasal fricatives	**6**
Velopharyngeal fricative	**3**
Weak/nasalised consonants	**18**
Nasal realisation of fricatives	**3**
Nasal realisation of plosives	**3**
Absent pressure consonants	**2**
Gliding of fricative and affricates	**0**

7.5.1 Active cleft speech characteristics

I. Anterior oral CSCs

7.5.1.1 Dental realisation related to cleft

In this section, dental realisation related to cleft were judged depending on the status of dental occlusion and the presence or absence of Class III malocclusion. Five children present with dental realisation of alveolar targets, including the emphatic fricative target /sˤ/. In this section, dental realisation refers to the production of a consonant with the tongue tip making a contact with the back of upper front teeth. Furthermore, lateral articulations (which will be discussed in the next section) have been noticed to occur in some of the children simultaneously with dental articulation (e.g. /sˤ/→[ɬ̪]), which, it is suggested to occur as a result of cleft-related occlusion (jaw alignment).

In Table 7.6, all dentalised articulations observed in children's speech have been included.

Table 7-6 Dental realisation related to cleft found in the data

Child Initial	Dentalisation	
AM	/s/→[s̪]	WM WF
	/s/→[ɬ̪]	WI WF
	/sˤ/→[ɬ̪]	WI WM WF
	/s /→[ɬ̪]	WI WM WF
	/sˤ/→[ɬ̪]	WI
	/sˤ/→[s̪]	WM WF
Gh	/s/→[s̪]	WM WF
	/s/→[ɬ̪]	WF
	/z/→[z̪]	WI WM
	/sˤ/→[ɬ̪]	WI WM WF
	/s/→[s̪]	WM
	/z/→[z̪]	WI
	/ʃ/ → [s̪]	WM
	/sˤ/→[ɬ̪]	WI WM WF
Me	/s/→[s̪͋]	WI WM WF
	/z/→[z̪]	WI
	/z/→[s̪͋]	WF
	/ʃ/→[s̪͋]	WI WM WF
	/sˤ /→[s̪͋]	WI WM WF
	/s/→[s̪͋]	WI WM WF
	/z/→[s̪͋]	WI WM WF
	/ʃ/→[s̪͋]	WI WM WF
	/sˤ /→[s̪͋]	WI WM WF
Mu	/s/→[ɬ̪]	WI
	/s/→ [s̪]	WM
	/s/→[s̪˜]	WF
	/sˤ/→[s̪]	WI
	/sˤ/→[ɬ̪]	WF
	/s/→[s̪̃]	WI WF
	/s/→[s̪]	WM
Sa	/s/→[s̪]	WI
	/s /→[ɬ̪]	WM WF
	/z/→[z̪]	WI WM
	/z/→[ʔɬ̪]	WF
	/sˤ/→[s̪]	WI WF
	/sˤ /→[ɬ̪]	WM
	/s /→[ɬ̪]	WI WM WF
	/sˤ /→[ɬ̪]	WI

7.5.1.2 Linguolabial articulation

Table 7-7 Linguolabial articulation found in the data

Child Initial	Linguolabial articulation	
Sa	/ð/→[d̼]	WI
	/d/→ [d̼]	WI
	/ð/→[d̼]	WM
	/n/→[ñ̼]	WI WM WF
Sau	/ð,θ/→[n̼]	WM WF
	/f/→[n̼]	WI WM
	/t/→[w̼]	WI
	/l/→[n̼]	WI
	/ʤ/→[n̼]	WI WM WF
	/dˤ,sˤ/→[n̼]	WI
	/tˤ/→[n̼]	WM WF
	/k/→[n̼]	WM
	/q/→[n̼]	WI WM
	/θ/→[n̼]	WI WM WF
	/z/→[n̼]	WI WM WF
	/ʃ/→[n̼]	WI
	/ʃ/→[n̼ʰ]	WF
	/dʒ/→[n̼]	WF
	/sˤ/→[n̼]	WI WM WF
	/tˤ/→[n̼]	WI
	/ðˤ/→[n̼]	WI WM
	/ k/→[n̼]	WI WM WF

When consonants are produced by placing the tongue tip or blade between the upper and lower lips, they are described as having linguolabial place of articulation. In the ExtIPA, linguolabial articulation is transcribed using a diacritic which resembles the shape of the upper lip e.g. [t̼ d̼ θ̼]. As shown in the Table 7-7, only two children presented with such behaviour. For both children, linguolabial articulation was noticed in different segments across word positions. As an example, in the word /ðɛːl/, Sa produced the target /ð/ with a stop as a dialectal variant but produced with a linguolabial place of articulation rather than dental or alveolar. On the other hand, Sau has a tendency to produce almost all of the target consonants nasally with linguolabial placement as the place of articulation (see Table 7-6).

7.5.1.3 Lateralisation/lateral articulation

Table 7-8 Lateral articulation found in the data

Child Initial	Lateral articulation	
AG	/s/→[ɬ]	WF
	/ʃ/→[ɬ]	WF
	/sˤ/→[ɬ]	WF
	/ʃ/→[ɬ]	WM WF
AM	/s/→[ɬ̪]	WI WF
	/z/→[ɮ]	WM
	/ʃ/→[ɬ]	WI WM WF
	/ʤ/→[ɮ]	WM
	/sˤ/→[ɬ̪]	WI WM WF
	/s/→[ɬ̪]	WI WM WF
	/z/→[ʔɮ]	WF
	/ʃ/→[ɬ]	WM WF
	/ʤ/→[ɮ]	WI WF
	/sˤ/→[ɬ̪]	WF
Gh	/s/→[ɬ̪]	WF
	/z/ →[ɮ]	WF
	/ʤ/→[[ɮ]	WF
	/sˤ/→[ɬ̪]	WI WM WF
	/z/ →[ɮ]	WM WF
	/ʃ/→[ɬ]	WF
	/ʤ/→[ɮ]	WI WM WF
	/sˤ/→[ɬ̪]	WI WM WF
Ma	/z/ →[ɮ]	WI WM WF
Mis	/ʃ/→[ɬ]	WM
	/z/ →[ɮ]	WI WM WF
Mon	/ʃ/→[ɬ]	WF
	/ʤ/→[ɮ]	WF
	/ʃ/→[ɬ]	WM WF
	/ʤ/→[ɮ]	WF
Mu	/s/→[ɬ̪]	WI

	/z/ →[ɬ] /ʃ/→[ɬ] /sˤ/→[ɬ]	WF WI WM WF WM WF
	/ʃ/→[ɬ] /ʤ/→[ɮ]	WF WF
Sa	/s/→[ɬ̪] /z/ →[ʔɬ̪] /ʃ/→[ɬ] /sˤ/→[ɬ̪]	WM WF WF WI WM WF WM
	/s/→[ɬ̪] /z/ →[ʔɬ] / sˤ/→[ɬ̪] /sˤ/→[ɬ]	WI WM WF WF WI WM WF WM WF

As apparent from Table 7.8, above, fricatives and affricate /s, sˤ, z, ʃ, ʤ/ tend to be lateralised frequently in different word positions and mostly in word-final position (i.e. number of occurrences in each word position: 33% WF, 20.5% WM, and 12.5% WI). The following examples are taken from some of the children:

- Child Gh: /ʤ/ realised as [ɮ] (WF) e.g. /daʤa:ʤ/→[daʒa:ɮ]
- Child Mis: /ʃ/ realised as[ɬ] (WM) e.g. /fara:ʃah/→[fara:ɬah]
- Child Sa: /s / realised as [ɬ̪] (WM) e.g. /ʔas.na:n/ →[ʔɛ ɬ̪.nu] ([ɬ̪] = lateral interdental fricative).
- Child Gh: /sˤ/ realised as [ɬ̪] (WI) e.g. /sˤa:bu:n/→/[ɬ̪ a:bu:n]
- Child AM: /z/ realised as [ɮ] (WM) e.g. /ʤazar/→[ʒaɮar]

It has been noted that when a lateral production of a given consonant occurs in one position (e.g. word-initial position) it is not necessary for the lateral process to occur in all word positions. This observation is not limited to lateral articulation: it applies to almost all features included in this chapter. That is, intact production could occur in, for example, word-initial position with articulation errors related to typical speech development in the word-medial position and an error related to cleft palate in the word- final position. An example is provided by Child Mon, who produced/ʃ/ correctly in word-initial position as in [ʃahi] 'tea', but lateralised in word-final position as in [riɬ] 'feather'.

7.5.1.4 Palatalisation/ palatal articulation

Table 7-9 Palatal articulation found in the data

Child Initial	Palatal articulation	
Gh	/ʃ/→[ç]	WM WF
	/s/→[ç] /ʃ/→[ç]	WI WF WI
Sa	/ʃ/→[ç]	WI WM WF

Palatal articulations (i.e. voiceless palatal fricative) appear to be one of the least commonly occurring features in the data, since only two children used palatal fricative as a replacement for only voiceless targets:

- Child Gha realised /s/ as [ç] in all word positions e.g. /ʁasalatsa:raəl.mala:bɪs/→[ç ç ç]
- Child Sa realised / ʃ / as[ç] (WM) e.g. /fara:ʃah/→ [fara:çah]

Palatal stops have not been observed in the data.

7.5.1.5 Double articulation

Table 7-10 Double articulation found in the data

Child Initial	Palatal articulation	
Nas	/sˤ/→[ʔ͡q]	WM
Sa	/ tˤ/→ [t͡q]	WI

Out of 21 children, the data showed that, according to perceptual analysis, only two children presents with double articulation. This id revealed in the following single examples for each child:

Child Nas:/ sˤ/ released as [ʔ͡q] (WM): /ʕasˤiːr/→[ʕaʔ͡qiːɾ] 'juice'

Child Sa: / tˤ/ released as [tˤ͡q] (WI): /tˤɪj.jaːrah/→[tˤ͡qɪj.jaːɾah] 'plane'

The occurrence of double articulations in only two children may be a case of underreporting, as this process is hard to identify just by using perceptual analysis (Howard and Pickstone, 1995; Gibbon and Crampin, 2002).

II. Posterior CSCs

7.5.1.6 Backing

According to the literature, "backing" is considered to be the most frequently occurring phonological process in children with cleft palate (e.g., Chapman, 1993; Peterson-Falzone *et al.*, 2001; Russell and Grunwell, 1993). Following the GOS.SP.ASS classification (Arabic version), backing has been classified into two categories: *backing within the oral cavity*, where dental and alveolar pressure consonants (i.e. obstruents) are retracted to palatal [c,ɟ ,ç,ʝ], velar [k,g,x,ɣ] or uvular [q,ɢ,χ,ʁ] place of articulation; and *backing of oral targets to post-uvular place of articulation*, where pressure consonants are retracted to pharyngeal [ʡ, ʕ, ħ] or glottal place [ʔ,h] of articulation.

- ***Backing within the oral cavity***

Only two types of backing were found within the oral cavity: backing to velar in two children and backing to uvular in four children. Tables (7.10) and (7.11) display patterns found for each child.

As revealed in Table (7-11), Child Sa used velar backing for the second part of the affricate sequence /ʤ/ in different word positions and on one occasion he substituted the entire affricate with a velar backing. Child Sh appeared to have more posterior placement in different word positions. Bilabial, alveolar, dental and emphatic targets were backed to uvular place of articulation. Three participants have it only once in their speech, while Child Sh used uvular backing from different target places of articulation (Table 7.12). According to the literature, posterior placements of anterior consonants usually occur for lingual place targets i.e. dentals, alveolar and post alveolars (Lawrence and Philips, 1975; Trost, 1981). Bilabial backing patterns adopted by Child Sh might be related to the observation of Gibbon and Crampin (2002) of school aged children with cleft palate who showed backing process of bilabials in early speech development, which turned at later stages into double articulations.

Table 7-11 Backing to velar

Child Initial	**Backing to velar**	
Sa	/ʤ/→[dg]	WI
	/ʤ/→[g]	WF
	/ʤ/→[dg]	WI WM WF
Sh	/ð/→ [ŋg]	WI
	/ð/→[g]	WF
	/b/→[g]	WM WF
	/ð/→[g]	WI WM
	/n/→ [ŋ]	WM
	/dˁ/→[g^{n}]	WI

Table 7-12 Backing to uvular

Child Initial	**Backing to uvular**	
AG	/tˁ/→ [q]	WM
Mis	/ð/→[q]	WM
Nas	/ðˁ/→[q]	WM
Sh	/dˁ/→[q]	WF
	/tˁ/→[q]	WM
	/b/ → [q]	WI

	/t/ →[q] /tˤ/→[q̃]	WM WF WM

- ***Backing of oral targets to post-uvular place of articulation***

Backing to pharyngeal: None of the children used the process of pharyngeal articulation for nonpharyngeal targets. When considering the realisation of pharyngeal targets, they tend to be accurately produced although some of the children produced /ħ,ʕ/ at other place of articulation (i.e. /ħ/→[h], /ʕ/→[ʔ]). The voiced pharyngeal /ʕ/ is one of the latest consonants to be acquired by Arabic children (>6; 4), whereas the voiceless pharyngeal /ħ/ is usually acquired early (i.e. <2:0 to 3:10) (Amayreh, 1998).

Backing to glottal: Glottal articulation is the third most frequently used cleft palate characteristic in the study, as it was used by nine children. It occurred as a realisation of stops /t, d, tˤ, dˤ, k/, fricatives /θ, ð, f, s, z, ʃ/ and the affricate /ʤ/ which is similar to what has been reported by Trost-Cardamone (1997) in English. As shown in Table (7.13), the glottal stop [ʔ] was observed to be more commonly used as a glottal replacement than the glottal fricative [h]. Examples are taken from some of the children that used glottal articulation as a replacement:

- Child Nas: /k/ and /t/ realised as [ʔ](WI) (WM) e.g. /kɪta:b/→[ʔɪʔa:(b)]
- Child Sau: /z/ released as [ʔ] (WI) e.g. /zara:fah/→[ʔana:nah]
- Child Nas /f / released as [h](WF) e.g. /χaru:f/→ [xawu:h]

Table 7-13 Glottal articulation

Child Initial	Glottal articulation	
AG	/tˤ/→[ʔ]	WI WM WF
	/tˤ/→[ʔ]	WI WM WF
	/dˤ/→[ʔ]	WF
Me	/t/→[ʔ]	WM
	/ tˤ/→[ʔ]	WM WF
	/k/→[ʔ]	WI WM
	/q/→[ʔ]	WM
	/ tˤ/→[ʔ]	WI WM
	/k/→[ʔ]	WI WM WF
	/q/→[ʔ]	WI WM WF
Moh	/ʤ/→[ʔ]	WM
Mon	/dˤ/→[ʔ]	WI
	/ tˤ/→[h]	WI
	/ tˤ/→[ʔ]	WM
	/t/ →[ʔ]	WI
	/ʤ/→[h]	WI
	/tˤ/→[ʔ]	WM
Mu	/ð/→[h]	WI WM
Nas	/f/→[ʔ]	WI WM
	/f/→[h]	WF
	/ð/→[ʔ]	WI WM
	/θ/→[ʔ]	WI WM WF
	/t/→[ʔ]	WI WM
	/d/→[ʔ]	WI WM
	/s/→[ʔ]	WI
	/s/→[h]	WF
	/ʃ/→[ʔ]	WI WM
	/ʃ/→[h]	WF
	/ʤ/→[ʔ]	WI WM WF
	/sˤ/→[ʔ]	WI
	/sˤ/→[h	WF
	/dˤ/→[ʔ]	WI WM WF
	/tˤ/→[ʔ]	WI WM
	/ðˤ/→[ʔ]	WI WM
	/k/→[ʔ]	WI WM WF
	/f, t, z ,ð, ʃ ,θ ,dˤ/→[ʔ]	WI WM WF
	/d, s, ʃ ,ʤ, k, q, sˤ, tˤ/→[ʔ]	WI WM
	/sˤ,k,ʃ/→[h]	WF

Re	/d/→[ʔʰ]	WF
Sa	tˤ/→[ʔ]	WF
Sau	/ð/→[ʔ]	WI
	/z/→[ʔ]	WI
	/q/→[ʔ]	WF
	/q/→[ʔ]	WI WM

7.5.1.7 Active nasal fricatives

Table 7-14 Active nasal fricatives/affricate

Child Initial	**Active nasal fricative/ affricate**	
Da	/s/→ [ñ̥]	WF
Moh	/s/→ [ñ̥̇]	WI WM
	/sˤ/→[ñ̥̇]	WI WF
	/s/→ [ñ̥̇]	WF
	/sˤ/→[ñ̥̇]	WI WM WF
Mon	/f/→ [ñ̥]	WF
Nah	/s/→ [ñ̥]	WI WF
Sa	/s/→ [ñ̥̇]	WF
Sh	/θ//→[ñ̥]	WI
	/f/→[ñ̥]	WI
	/s/→[ñ̥]	WI WM WF
	/z/→[ñ̥]	WI WF
	/ʃ/→[ñ̥]	WI
	/ʤ/→[ñ̥]	WI
	/ʤ/→[d̥ ñ̥]	WF
	/sˤ/→[ñ̥]	WI WF
	/f/→[ñ̥]	WI WM WF
	/s/→[ñ̥]	WI WM WF
	/z/→[ñ̥]	WI WM WF
	/ʃ/→[ñ̥]	WI
	/sˤ/→[ñ̥]	WI WF

Nasal emission and/or turbulence were used to replace some of the voiced and/or voiceless fricatives. These realisations are referred to as active nasal fricatives because the airflow of the target fricative is stopped orally and is actively directed nasally. This was noticed in six children in different word positions.

7.5.1.8 Velopharyngeal fricative

Table 7-15Velopharyngeal fricative

Child Initial	Velopharyngeal fricative	
Da	/t /→ [fŋ]	WF
Me	/t /→ [fŋ]	WI
Sh	/t/ →[fŋ]	WI
	/ʤ/→[fŋ]	WI
	/ʤ/→[fŋ]	WF
	/dˤ/→[fŋ]	WI

The data of three children show nasal turbulence as a replacement for target plosives and/or affricate such as /t, dˤ, ʤ/. Basically what can be perceived in the velopharyngeal fricative is the occurrence of nasal turbulence and nothing else. This speech behaviour is suggested to be an active strategy and its occurrence is limited in the literature.

7.5.2 Passive cleft speech characteristics

7.5.2.1 Nasalised and weak consonants

Table 7-16 Nasalised and weak consonants

Child Initial	Weak/ nasalised consonants	
AG	/b/→[b̹]	WF
	/dʒ/→[ʒ̹]	WF
	/dˤ /→[d̹ˤ]	WM
AM	/b/→[b̹]	WF
	/f/→[f̹]	WF
	/dˤ /→[d̹ˤ]	WF
	/ʤ/→[d̹k’]	WF
	/ðˤ/ →[ð̃ˤ]	WI

Da	/dʒ/→[d͉]	WF
Gh	/q/→[ɡ͉]	WF
Jo	/t/→[t͉ʰ]	WF
	/sˤ/→ [θ̆]	WM WF
	/dˤ/→[ð͉ˤ]	WM
Me	/b/→[b͉]	WM WF
	/dʒ/→[ʒ ͉]	WF
	/q/→[d͉]	WI
	/b/→[b͉]	WM WF
	/ð/→ [đ]	WI
	/d/→[d͉]	WI WM WF
	/z/→[ð͉]	WF
	/dʒ/→[ʒ ͉]	WM
	/dˤ/→[ð͉ˤ]	WM
Mis	/f/→[f͉]	WF
	/d/→[d͉]	WF
Moh	/t/→ [t̆]	WM
	/dʒ/→[dʒ ͉]	WF
	/b/→ [b̆]	WI WM
	/z/→[ð̆]	WI WM WF
	/q/→[q ͉]	WF
Mon	/b/→[b͉]	WF
	/t/→ [t͉]	WF
	/ð/→[ð͉]	WI
	/dʒ/→ [đ]	WI
	/dʒ/→[ʒ ͉]	WM
	/sˤ/→ [θ͉]	WI
	/dˤ/→[b͉]	WM
	/ðˤ/→[ð͉ˤ]	WM
	/b/→[b͉]	WM WF
	/d/→[d͉]	WI WF
	/θ/→ [θ͉]	WF
	/s/→ [θ͉]	WI WM
	/dˤ/→[ð͉ˤ]	WM
	/ðˤ/→[ðˤ]	WI
	/k/→ [k͉]	WI WM WF
Mu	/ð/→[ð͉]	WF
	/d/→[d͉]	WF
	/dˤ/→[ð͉ˤ]	WF
	/tˤ/→[t͉ˤ]	WF

	/t/→ [t̞]	WF
Nah	/f/→[f̞]	WF
Nas	/ð/→[d̞]	WF
	/s/→[t̞ ʰ]	WM
Os	/ʁ/→[g̞]	WF
Re	/dʒ/→[dʒ ̞]	WF
Sa	/t/→[t̞]	WI
	/k/→[k̞]	WF
	/q/→[g̞]	WF
	/t/→[t̞]	WF
	/d/→[d̞]	WF
	/dˤ/→[d̞ˤ]	WM WF
	/ðˤ/→[ðˤ̃]	WI WM
Sau	/b/→[b̞]	WF
	/z/→[d̞ˤ]	WF
	/sˤ/→[d̞ˤ]	WF
	/sˤ/→[dˤ̃]	WM
	/dˤ/→[d̞ˤ]	WF
	/ðˤ/→[d̞ˤ]	WM
	/b/→[b̞]	WI
	/d/→[d̞]	WI WM WF
	/dˤ/→[d̞]	WM WF
Sh	/b/→[b̞]	WF
	/d/→[d̞]	WM WF
	/dʒ/→[d̞ŋ̊̃]	WF
	/dˤ/→[ð̞ˤ]	WM
	/ðˤ/→ [ð̞̃]	WM
	/d/→[d̞]	WI
	/ð/→ [g̞̃]	WI WM
	/dʒ/→[d̞g̃]	WM WF
	/dˤ/→[g̃]	WM
	/χ/→ [x̃]	WM

In contrast to other cleft palate speech features, the child's realisation of consonants could be intact but weakened. As shown in Table (7.15), weak and/or nasalised articulation is the most frequently-occurring process in the data. The processes are passive cleft-type speech features which have been frequently reported in cleft studies (Henningsson *et al*., 2009). Weak and/or nasalised articulation were applied to different target sound types, however, in some, but not all, manner and places of articulation. It is possible that weakened or nasalised production of target consonants occur as a result of structural abnormality (VPI) which leads to pressure leak at the velopharyngeal port and thus results in a loss of power in the production of high-pressure consonants.

7.5.2.2 Nasal realisation of fricatives and/or affricate

Table 7-17 Nasal realisation of fricatives and/or affricate

Child Initial	**Nasal realisation of fricatives and affricate**	
AM	/ðˤ/→[n]	WF
Mon	/χ/→[ŋ]	WM
Sau	/θ/→[n̪]	WM
	/ð/→[n̪]	WM
	/f/→[n̪]	WI WM
	/s/→[n]	WM
	/z/→[nʔʰ]	WF
	/sˤ/→[n̪]	WI
	/θ/→[n̪]	WI WM WF
	/ð/→[n]	WI WM WF
	/f/→[n]	WI WM WF
	/s/→[n]	WI WM WF
	/z/→[n̪]	WI WM WF
	/ʃ/→[n̪]	WI
	/ʃ/→[n]	WM
	/ʃ/→ [n̪ʰ]	WF
	/ʤ/→[n]	WI WM
	/ʤ/→[n̪]	WF
	/sˤ/→[n̪]	WI WM WF
	/ðˤ/→[n̪]	WI WM WF

As can be seen from Table (7-17), only three children replaced fricatives /f, s, z, ʃ, ð, θ, sˤ, ðˤ/ and affricate /dʒ/ with nasal consonants. Child Sau, in particular, produced most of his fricatives and affricates as nasals especially during the sentence repetition task.

7.5.2.3 Nasal realisation of plosives

Table 7-18 Nasal realisation of plosives

Child Initial	Nasal realisation of plosives	
Mon	/b/→[m]	WI WM
Nas	/b/→[m]	WI WM WF
	/b/→[m]	WI WM WF
Sau	/b/→[m]	WI WM
	/t /→[n]	WM
	/dˤ/→[n̠̼]	WI
	/tˤ/→[n̠̼]	WM WF
	/k/→[n̠̼]	WI WM
	/q /→[n̠̼]	WI WM WF
	/b/→[m̠̥]	WM WF
	/t /→[n]	WI WM WF
	/dˤ/→[n]	WI
	/tˤ/→[n̠̼]	WI
	/tˤ/ →[n]	WM
	/k/→[n̠̼]	WI WM WF

Stengelhofen (1989) reported that nasal realisations of plosives occur as a result of reduced intraoral pressure. Three children used this process of nasal preference especially with the production of the bilabial stop. Child Mon and Child Nas only used it for the bilabial consonant /b/. Other sound productions of Child Nas's tend to be glottalised in different word positions whereas Child Mon has a mixture of developmental errors as well as lateralised productions of fricative sounds in certain positions. Child Sau has a clear tendency to replace a number of plosives (i.e. /b, k, t, q, dˤ, tˤ/) with nasals in the production of both single words and sentences.

7.5.2.4 Absent pressure consonants

A speech profile that has been reported for some children with cleft palate is where the child's phonetic repertoire mainly consists of weak nasalised consonants, together with nasalised fricatives and plosives. Thus, there is an absence of pressure consonants. The phonetic repertoire is characterised by an extremely narrow range of speech patterns consisting of a very limited variety of consonants: nasals and approximants with the possibly occurrence of non-oral fricatives. Two children, Child Nas and Child Sau, presented with such a speech profile. Child Nas's speech output consists mainly of glottals, along with nasal replacement of the bilabial stop. Child Sa has a predominance of nasal articulations for most of his fricatives and stops and also glottal replacement of the uvular stop and dental fricative, restricted to word- initial position.

7.5.2.5 Gliding of fricatives and plosives

None of the children replaced fricative consonants with glides.

7.6 Other cleft speech characteristics

7.6.1 Ejectives

The data also showed processes which have not yet been noted in the cleft literature. One of these processes, found in four children's speech data, involved the use of ejectives (Table 7.19). The target voiced bilabial stop was realised as [p'] by three children. This realisation was restricted to word-final position. Furthermore, in the speech of one child, /d/ was substituted by a weakened alveolar plosive [d̹] (i.e. developmental error) along with the production of velar ejective [k'] also in the word- final position. e.g. /dædʒadʒ/→[/dædʒad̹k'] .

Table 7-19 Ejectives presented in all data

Child Initial	Ejectives	
AM	/ʤ/→[d̹k']	WF
Os	/b/→[p']	WF
Re	/b/→[p']	WF
Sa	/b/→[p']	WF

7.6.2 Strong articulation

Table 7-20 Strong articulation

Child Initial	**Strong articulation**	
Ma	/t ,s/→ [θ͈] /z, sˤ, ʤ, ʃ/→[θ͈] /ʃ/→[ç͈]	WF

Strong articulation has been noticed as an additional speech behaviour which occurs in one child. Child Ma tends to use strong articulation frequently when producing certain consonants only (Table 7.20) in word-final position and during picture-naming production of single words rather than sentence repetition. Such behaviour might be an artefact of the clinical situation. It is worth pointing out that all of the realised strong consonants are fricatives (i.e. [θ͈, ç͈]), however if plosives are realised with increased force they could be misperceived and identified as ejectives.

7.7 Introduction to Developmental Phonological Processes and Phonological Analysis

In addition to speech errors which occur as a consequence of structural abnormality (i.e. cleft palate), children with cleft palate are also at risk of phonological disorders (Chapman, 1993). This section takes a phonological perspective on the speech data, exploring patterns of typical and delayed phonological development, as well as phonological processes specifically related to cleft palate. It is essential to make a careful distinction between those processes that relate to normal or delayed phonological development which have nothing to do with any structural abnormality and those errors related to a history of cleft palate and/or associated hearing issues (Harding and Grunwell,1998).

For the purpose of this analysis, in order to enable comparisons with typical development, there are two groups of participants: the 21 children with cleft palate, whose data have already been explored in this chapter, together with a control group of four typically developing children. Details of the participants were provided in Chapter 5. Each of the individual GOS.SP.ASS cleft speech features, based on analysis of the single word assessment and GOS.SP.ASS sentences, are presented as group results (e.g. 11/21 children used de-affrication; 8/21 children used stopping; see Table 7-21) together with some illustrative words from individual children.

A phonological processes framework has been used in order to describe the participants' speech (cleft groups and controls). This has been widely used in the literature to describe errors produced by both normally developing children (Ingram, 1976) and phonologically disordered children (e.g. Grunwell, 1987, Miccio and Scarpino, 2008), as well as children with a history of cleft palate (Grunwell and Russell, 1988; Chapman, 1993; Harding and Howard, 2011). Phonological process analysis is the most common approach to phonological analysis in cleft. Furthermore, this framework has also been used to identify, describe, and categorise phonological patterns across various languages, including Arabic (Amayreh and Dyson, 1998, 2000; Grunwell, 1997; Zhu and Dodd, 2006). Thus in the current study, phonological processes have been used to describe the patterns found in the participants' speech.

A phonological processes can be defined as the child's use of simpler forms in place of adult speech productions. They have been described by Ingram (1976) as "simplifying processes that affect entire classes of sounds".Phonological processes can affect the structure of phonological units as well as the system of phonological contrasts. Examples of systemic simplifications (substitution processes) are fronting, stopping and de-affrication whereas structural processes (word and syllable level processes) may include final consonant deletion or deletion of unstressed syllables (Ingram, 1976). Here, descriptions of both systemic and structural processes are provided for each participant.

It is important to note that in the present study, when two or more simplifications co-occur within the same word, each of the errors is included in the error analysis. For example, the realisation /dʒæzær/→ [dæzæl] 'Carrot' contains two simplification errors, namely de-affrication and liquid replacement. This approach is important in that it makes possible identification of structural and systemic errors that occur within the same word, or of two systemic errors that combine to affect the production of particular words or individual sounds (Grunwell, 1997). Some types of substitutions have not been included in the analysis as they are acceptable variants related to dialectal differences, e.g. /θ/ →[s], /dˤ/ →[ðˤ], /r/ →[ɾ], /dʒ/ →[ʒ], /ðˤ/ →[dˤ] (Amayreh and Dyson, 1998); Dyson and Amayreh, 2000). For full lists of acceptable variants, see Appendix 5.

7.8 Systemic Processes Affecting Children with Cleft Palate and control group

Systemic (substitution) processes found in the speech of the participants and controls are listed in Table 7-21.

Table 7-21 Number of children using substitution process in different word positions

Substitution Process	**Cleft group**		**Control group**	
	(*n*=21)	**%**	**(*n*=4)**	**%**
Stopping	8	38 %	1	25%
Non-cleft dentalisation	16	76.2%	2	50%
De-pharyngealisation	10	47.6%	3	75%
De-affrication	11	52.3%	2	50%
Affrication	2	9.5%	0	0%
Non-cleft pharyngeal backing	8	38%	2	50%
Palato-alveolar fronting	5	23%	1	25%
Velar fronting	2	9.5%	0	0%
Gliding	4	19%	0	0%
Lateralisation of /r/	6	28.5%	1	25%
Context sensitive voicing and devoicing	6	28%	1	25%

7.8.1 Stopping

Stopping refers to replacement of fricatives by stops. Examples of stopping in different word positions and number of children in both groups (cleft and control groups) using this process are given in Tables 7-22 and 7-23. As noted earlier, some stopping processes occur as acceptable dialectal variants e.g. /ð/→[d], /ðˤ/→[dˤ], /ʁ/→[g] (Amayreh and Dyson, 1998; (Dyson and Amayreh, 2000). From the cleft group, Child Ta's speech in particular involves frequent occurring of stopping that occur as acceptable dialect variants and thus are not considered as typical or atypical developmental processes nor related to cleft palate.

Eight children with cleft palate presented with the stopping process (Table 7-22 and Table 7-23), whereas in the control group the process occurs in only one instance for one child in the target word /mɛʁ.sælæh/, where the voiced velar fricative /ʁ/ was realised with a voiced velar plosive [g] and therefore this seems to be a very marginal process.

Table 7-22 Children presenting with stopping

Cleft group	**Child Initial**	**Stopping**	
	Da	/ð/→*[d]* /ðˤ/→[d]	WI WI
	Ma	/ð/→*[d]* /ðˤ/→[dˤ]	WI WI WM
	Mu	/z/→[d] /ð/→*[d]*	WI WF
		/ð/→*[d]* /ʁ/→*[g]*	WI WM WF WF
	Nah	/ðˤ/→[d]	WI
	Os	/ð/→*[d]*	WI
	Re	/z/→[d]	WM
	Sau	/ð/→[d̪]	WI WM

	Ta	/ð/→*[d]*	WI WM WF
		/ʁ/→*[g]*	WM
		/ðˤ/→[d]	WI
		/ðˤ/→[d]	WI WM WF
		/ʁ/→*[g]*	WM
Control group	Child M	/ʁ/→*[g]*	WM

Acceptable dialect variants are written in Italic

Table 7-23 Examples of stopping (Cleft group)

Child Initial		**Adult's form**	**Child's realisation**	**Translation**
Mu	**Examples**	/**z**ara:fah/	[**d**arã:fah]	Giraffe
Ta		/ma**ʁ**.salah/	[ma**g**.t͡salah]	Water sink
Re		/dʒa**z**ar/	[ʒa**d**ar]	Carrot
Da		/**ðˤ**ahar/	[**d**ãhar]	Back
Os		/na**ðˤ**.**ðˤ**ɑrah/	[na**tˤ**.**tˤ**ɑrah]	Eyeglasses

7.8.2 Non-cleft dentalisation

This category refers to the non-cleft dentalisation of alveolar targets, thus /**s**/, /**sˤ**/ /**ʃ**/ are replaced by [**θ**] and [**z**] by [**ð**]. In the cleft group, sixteen children presented with this process (Table 7-23). Child A and Child W in the control group replaced alveolar and postalveolar fricatives /s, z, ʃ, sˤ/ with dental fricatives consistently [θ,ð], both in single word and sentence productions.

Table 7-24 Children presenting with non-cleft dentalisation

	Child Initial	**Interdental articulation**	
Cleft group	AG	/s/→[θ]	WI
		/z/→[ð]	WI WM
	AM	/z/→[ð]	WI
		/z/→[ð]	WI
	Da	/s/→[θ]	WI
		/z/→[ð]	WM
		/sˤ/→ [θ˜]	WM

	/sˤ/→[θ]	WF
Di	/s/→[θ]	WM
	/z/→[ð]	WI WM
	/ʃ/→[θ]	WF
	/sˤ/→[θ]	WM
	/s/→[θ]	WI WM WF
	/z/→[ð]	WI WM WF
	/ʃ/→[θ]	WI WM WF
	/sˤ/→[θ]	WI WM WF
Jo	/s/→[θ]	WI
	/sˤ/→[θ]	WF
	/s/→[θ]	WI
	/s/→[θ̃]	WM
	/sˤ/→[θ̃]	WM WF
Ju	/s/→[θ]	WI WM WF
	/z/→[ð]	WI
	/sˤ/→[θ]	WI
	/sˤ/→[θ]	WI WM WF
	/z/→[ð]	WI
	/sˤ/→[θ]	WI WM WF
Ma	/s/→[θ]	WI WM WF
	/ʃ/→[θ]	WI
	/sˤ/→[θ]	WI WM WF
	/s/→[θ]	WI WM WF
	/z/→[ð]	WI
	/ʃ/→[θ]	WI
	/sˤ/→[θ]	WI WM WF
Me	/ʃ/→[θ]	WI
	/ʃ/→[θ̴]	WM WF
Moh	/s/→[θ]	WI
	/z/→[ð̴]	WM
	/sˤ/→[θ]	WI
	/s/→[θ]	WI WM
	/z/→[ð̴]	WI WM WF
Mon	/s/→[θ]	WI WF
	/z/→[ð]	WI
	/sˤ/→[θ]	WI
	/s/→[θ̞]	WI WM
	/z/→[ð̞]	WI WM
	/z/→[ð]	WI WM WF

		/ʃ/→[θ]	WI
	Mu	/z/→[ð]	WM
		/ʃ/→[θ]	WI
		/z/→[θ]	WM
		/ʃ/→[θ]	WM
	Nah	/s/→[θ̴]	WI WM WF
		/z/→[ð̴]	WI WM WF
		/ʃ/→[θ̴]	WI WM
		/sˁ/→[θ̴]	WI WM WF
		/s/→[θ]	WM
		/z/→[ð̴]	WI WM WF
		/ʃ/→[θ]	WI
		/ʃ/→[θ̴]	WM WF
		/sˁ/→[θ̴]	WI WF
		/sˁ/→[θ̴]	WM
	Os	/ʃ/→[θ]	WI
	Re	/s/→[θ̴]]	WI
		/z/→[ð]	WF
		/sˁ/→[θ̴]	WI WF
		/s/→[θ̴]]	WI WM WF
		/sˁ/→[θ̴]	WI WM WF
	Sau	/s/→[θ]	WI
		/ʃ/→[θ̴]	WM WF
	Sh	/s/→[θ̴]	WF
		/z/→[ð̴]	WM
		/ʃ/→[θ̴]	WF
		/sˁ/→[θ̴]	WI WM
		/ʃ/→[θ̴]	WM WF
Control group	Child A	/s/→[θ]	WI WM WF
		/z/→[ð]	WI WM WF
		/ʃ/→[θ]	WI WM WF
		/sˁ/→[θ]	WI WM WF
		/s/→[θ]	WI WM WF
		/z/→[ð]	WI WM WF
		/ʃ/→[θ]	WI WM WF
		/sˁ/→[θ]	WI WM WF
	Child W	/z/→[ð]	WI WM

Table 7-25 Examples of non-cleft dentalisation (cleft group)

Child Initial	Examples	Adult's form	Child's realisation	Translation
Mu		/sˤæn.duq/	[θʌn.gug]	Box
Ma		/dʒæzær/	[ʒæðær/	Carrot

Table 7-26 Examples of non-cleft dentalisation (control group)

Child Initial	Examples	Adult's form	Child's realisation	Translation
Child A		/dʒa:lɪs/	[ða:lɪθ]	Sitting
Child W		/sˤa:bu:n/	[θa:bu:n]	Soap

7.8.3 De-pharyngealisation

De-pharyngealisation is exclusively used with emphatics where the secondary articulation is absent. In the cleft group, the process was identified in ten children (Examples of de-pharyngealisation are given in Table 7-27). In the control group, de-pharyngealisation was used by three children (Child A, Child W, and Child M) in their realisations of /dˤ,sˤ,tˤ,ðˤ/. Child A and Child M used the process only in the word /dˤʊf.dæʕ/, where they simplified the emphatic consonant in the word-initial position by replacing it with the sound [d]; elsewhere they produced the emphatic consonant with the appropriate secondary articulation.

Emphatic sounds are considered to be one of the latest classes of consonants to develop in an Arabic-speaking child's phonetic repertoire, due to the fact that these consonants may require a high degree of articulatory competency which may not be available for children until the ages of seven to eight years (Amayreh, 2003).

Table 7-27 Children presenting with de-pharyngealisation

	Child Initial	**De-pharyngealisation**	
Cleft group	AG	/sˤ/→[s]	WI WM
		/dˤ/→[d]	WI WM
	AM	/dˤ/→[d]	WI WM
		/sˤ/→[s̪]	WF
	Da	/sˤ/→[s̃]	WM
		/ðˤ/→[d]	WI
		/sˤ/→[s]	WI
	Di	/sˤ/→[s]	WI WM
	Gh	/dˤ/→[ð]	WF
	Jo	/dˤ/→[d]	WI WM
	Mis	/sˤ/→[s]	WI WM
		/dˤ/→[d]	WI WM
		/dˤ/→[d]	WI WF
	Os	/dˤ/→[ð]	WI WM WF
		/sˤ/→[s]	WI WM WF
		/tˤ/→[t]	WM
		/ðˤ/→[ð]	WM
	Re	/sˤ/→[s̪]	WI WM WF
	Ta	/dˤ/→[d]	WI WM WF
		/sˤ/→[s]	WI WM WF
		/ðˤ/→[d]	WI WM
		/tˤ/→[d]	WM WF
		/dˤ/→[d]	WI WM WF
		/sˤ/→[s]	WI WF
Control group	Child A	/dˤ/→[d]	WI
	Child M	/dˤ/→[d]	WI
	Child W	/sˤ/→[s]	WI WM WF

Table 7-28 Examples of de-pharyngealisation (cleft group)

Child initial		Adult's form	Child's form	Translation
Ta	Examples	/bɛːdˤ/	[bɛːd]	Egg
Da		/sˤan.duːq/	[san.duːg]	Box
AG		/dˤɛf.daʕ/	[dɛf.daʕ]	Frog
Di		/sˤar.sˤuːr/	[sar.suːr]	Cockroach
AM		/dˤʊf.daʕ/	[dʊf.daʕ]	Frog
Jo		/dˤʊf.daʕ/	[dʊf.daʕ]	Frog
Os		/ʕasˤiːr/	[ʕasiːr]	Juice
Mis		/dˤɛf.daʕ/	/dʰɛf.daʕʰ]	Frog

Table 7-29 Examples of de-pharyngealisation (control group)

Child initial		Adult's form	Child's form	Translation
Child A	Examples	/dˤʊf.daʕ/	[dʊf.daʕ]	Frog
Child M		/dˤʊf.daʕ/	[dʊf.daʕ]	Frog
Child W		/sˤar.**sˤ**uːr/	[sar.**s**uːr]	Cockroach

7.8.4 De-affrication

It is interesting to find in the literature that different authors either do not use the term de-affrication at all, or they have conflicting definitions for it. For example, Dinnsen *et al.* (2011) describe it as an affricate being produced as a stop, whereas Dodd and Iacano (1989) and To *et al.* (2013) use it to indicate affricates being produced as fricatives. Bernhardt and Stemberger (1998) do not use the term de-affrication, but do describe both patterns.

It is also interesting to note that the different patterns of replacements of affricates are described in the literature using different terms. For example, some studies used the term 'stopping' to describe affricate being realised as an alveolar plosive (e.g. Dodd and Lacano, 1989), whereas, as described above, other studies use 'de-affrication' to describe the substitution of affricates by fricatives (e.g. Dodd and Lacano, 1989 ; To *et al.*, 2013).

In the adult Arabic phonetic inventory, there is only one affricate, which is postalveolar, and commonly transcribed /dʒ/ in phonemic notation. Depending on the dialect, de-affrication could be a perfectly normal variant where the affricate /dʒ/ is substituted by the fricative [ʒ]; or [dʒ] and [ʒ] can sometimes be used within the same dialect interchangeably. On such occasions, this would not be considered as a developmental error and thus these realisations were not counted in this section. With the participants' data, de-affrication was a commonly used simplification and it can be defined as a replacement of affricates by fricatives or stops (Rupela *et al.*, 2010). An affricate can basically be defined as a compound speech sound consisting of a stop phase followed by a fricative release phase at the same place of articulation. The child can simplify the use of the complex consonant (/dʒ/) by simply producing only one of the two phases of the target (e.g. [d] or [ʒ]) or use that single phase to produce the complex consonant but with additional simplification (e.g. /dʒ/→ [ʒ]→[ð]).

As reported by Amayreh (2003), the affricate tends to be substituted by [z], [d], [ʃ], or [ð] and such productions are considered not to be acceptable among dialects of adult speech. In the current data it was noticeable that affricate was more frequently replaced by stops (i.e. [d]) than by fricatives ([ð,z,**s**,θ,ʃ]). Examples of de-affrication for the cleft group are given in Table 7-31 below where eleven children applied this process (see Table 7-30).

In the control group, the process was used by Child A and Child W. While Child A used it consistently for most of the single words containing the target consonant /dʒ/, using the fricative [ð] or plosive [d] as a substitution i.e. /dadʒaːdʒ/ →[daðaːð] and /dʒʊb.næh/→[dʊb.næh]), Child W used it only once in a single target word /dadʒaːdʒ/ 'chicken' realised as [dazaːz].

Table 7-30 Children presenting with de-affrication

	Child Initial	De-affrication	
Cleft group	AM	/dʒ/→[d]	WI
	Da	/dʒ/→[d] /dʒ/→ [ð]	WI WF WI WM
	Di	/dʒ/→[d] /dʒ/→ [ð] /dʒ/→ [z]	WI WI WM WF WI
	Ju	/dʒ/→[d] /dʒ/→[s]	WI WI WF
	Ma	/dʒ/→ [ð]	WI
	Me	/dʒ/→[d]	WI
	Mu	/dʒ/→[d]	WI
	Nah	/dʒ/→[d]	WI
	Os	/dʒ/→[d]	WI WM WF
	Sh	/dʒ/→ [ð̌]	WI
	Ta	/dʒ/→[d] /dʒ/→ [z] /dʒ/→[d] /dʒ/→ [z]	WI WI WI WF
Control group	Child A	/dʒ/→ [ð] /dʒ/→ [θ] /dʒ/→[d] /dʒ/→[d] /dʒ/→ [ð]	WI WM WF WF WI WI WM WF
	Child W	/dʒ/→ [z]	WM

Table 7-31 Examples of de-affrication (cleft group)

Child initial		Adult's form	Child's form	Translation
Mu	Examples	/dʒazar/	[daðal]	Carrot
Ju		/dʒa:lɪs/	[da:lɪs̪]	Sitting
Ta		/rɛdʒ.dʒa:l/	[lɛz.za:l]	Man
Da		/dʒa:lɪs/	[da:lɪs]	Sitting
Sh		/dʒʊbʊn/	[ðʊb.nah]	Cheese
Di		/dʒaras/	[daras]	Bell
AM		/dʒaras/	[daraɬ]	Bell
Os		/dadʒa:dʒ/	[dad̰̃a:d]	Chicken
M		/daradʒ/	[daraθ]	Stairs
Nah		/dʒaras/	/daraθ̃ /	Bell
Me		/dʒaras/	/daraθ̆/	Bell

7.8.5 Affrication

There was no affricated realisation of target plosives but only for fricatives which were evident in two children with cleft palate (See Tables 7-32 and 7-33). For the control group, none of the children used the process of affrication.

Table 7-32 Children presenting with affrication

	Child Initial	Affrication
Cleft group	Jo	/z/→[d͡z]
	Ta	/sˤ/→[d͡s]

Table 7-33 Examples of affrication

Child initial		Adult's form	Child's realisation	Translation
Ta	Examples	/ʕasˤi:r/	[had͡s̪i:l]	Juice
Jo		/mɔz/	[mɔd͡z]	Banana

7.8.6 Non-cleft pharyngeal backing

Backing to pharyngeal is the replacement of front sounds (e.g. alveolar) with a posterior placement. It has been described by Grunwell (1987) and Dodd *et al*. (2005) as an abnormal phonological process. In cleft speech, backing to pharyngeal involves abnormal backward placements of front oral targets to the pharyngeal place of articulation (Sell *et al*., 1994).

However, it has been noticed that there are language-specific rules as backing to pharyngeal is considered as a normal developmental process that occur in typically developing Arabic-speaking children. The process occurs for the sake of adopting an easier process for producing the target uvular sounds. For example, in Amayreh and Dyson's (1998) study uvular fricatives did not develop until the intermediate age (4:0 to 6:4).

Therefore, it is essential to make a distinction between the non-cleft pharyngeal backing that occurs as a result of normal phonological development in Arabic, and pharyngeal backing that occurs in relation to a history of cleft palate. Thus, in the latter, backing occurs for front oral sounds to pharyngeal place of articulation, whereas in the former backing occurs for uvulars to pharyngeal place of articulation.

Examples of non-cleft pharyngeal backing for the cleft group are given in Table 7-35 below where eight children applied this process (see Table 7-34). For the control group, pharyngeal backing was also used by a two children (i.e. Child A and Child M). Child A used [ʕ,ħ] interchangeably as replacements for voiceless and voiced uvulars, whereas Child M made a simplification process by replacing the uvular consonant with a more posterior consonant (i.e. pharyngeal) (e.g. /ʁas.saːlah/→ [ʕas.saːlah]). In general, Child M has a very few noticeable phonological errors which occur in only single word production (see Table 7-36 for examples).

Table 7-34 Children presenting with non-cleft pharyngeal backing

	Child Initial	Backing to pharyngeal	
Cleft group	Di	/χ/→[ħ]	WI
		/ʁ/→[ħ]	WF
	Me	/χ/→[ħ]	WI
		/χ/→[ħ]	WM
	Mis	/ʁ/→[ʕ]	WI
		/χ/→[ħ]	WF
		/χ/→[ħ]	WI WM
		/ʁ/→[ʕ]	WF
	Mu	/χ/→[ħ]	WM
		/χ/→[ħ]	WI WM
	Nah	/ʁ/→[ʕ]	WF
		/χ/→[ħ]	WF
	Nas	/χ/→[ħ]	WI WM WF
	Sau	/ʁ/→[ʕ]	WI WM WF
		/χ/→[ħ]	WI WM WF
	Ta	/χ/→[ħ]	WI
		/ʁ/→[ʕ]	WI
Control group	Child A	/χ/→[ħ]	WI WM WF
		/ʁ/→[ʕ]	WI WM
		/ʁ/→[ħ]	WF
		/χ/→[ħ]	WI WM WF
		/ʁ/→[ʕ]	WI WM WF
	Child M	/ʁ/→[ʕ]	WI

Table 7-35 Examples of non-cleft pharyngeal backing (cleft group)

Child initial		Adult's form	Child's form	Translation
Mu	**Examples**	/ʔa**χ**.dˤar/	[ʔa**ħ**.dˤaʟ]	Green
Ta		/**χ**aru:f/	[**h**alu:f]	Sheep
Di		/ʃʊma:**ʁ**/	[θʊma:**ħ**]	Saudi uniform
Me		/**χ**aru:f/	[**ħ**aru:(f)]	Sheep
Mi		/mɛ**ʁ**.salah/	[mɛ**ʕ**.salah]	Water sink
Nah		/matˤ.ba**χ**/	[matˤ.ba**ħ**]	Kitchen
Nas		/mɛ**ʁ**.salah/	[mɛ**ʕ**.ʔalah]	Water sink

Table 7-36 Examples of non-cleft pharyngeal backing (control group)

Child initial	Examples	Adult's form	Child's form	Translation
Child A		/χɪja:r/	[ħɪja:r]	Cucumber
Child M		/ʁas.sa:lah/	[ʕas.sa:lah]	Washing machine

7.8.7 Fronting processes

Two patterns of fronting were observed: palato-alveolar fronting and uvular as well as velar fronting (Table 7-37). Palato-alveolar fronting affects fricatives, whereas uvular/velar fronting affects stops. In the cleft group, palato-alveolar fronting was found in five children who replaced the post-alveolar fricative /ʃ/ with an alveolar fricative [s]. Examples of palato-alveolar fronting in different word positions are given in Table 7-38. Uvular/velar fronting was less frequent than the palato-alveolar fronting, occurring in only two children (see Table 7-39). One child used both types of fronting in a persistent way throughout his speech. According to a study conducted by Dyson and Amayreh (2000), fronting disappears for typically-developing Arabic-speaking children from around the age of 3:5, which suggests a pattern of delayed phonological development for the children reported here.

In the control group, none of the children used velar fronting, whereas postalveolar fronting was used only in one child out of four children (see Table 7-40).

Table 7-37 Children with fronting processes

	Child Initial	Fronting process	
Cleft group	AG	/ʃ/→[s]	WI
	Di	/ʃ/→[s]	WI WM
	Ju	/ʃ/→[s]	WM
	Me	/ʃ/→[s] /q/→ [d̪]	WM WI
	Mon	/q/→ [d̪]	WI
	Nah	/ʃ/→[s]	WM WF

	Os	/ʃ/→[s]	WI WM
	Ta	/ʃ/→[s] /k/→[t] /ʃ/→[s] /k/→[d] /k/→ [t]	WI WF WI WM WM WF WM WF WI
Control group	Child W	/ʃ/→[s]	WI

Table 7-38 Examples of palato-alveolar fronting (cleft group)

Child initial	Examples	Adult's form	Child's form	Translation
Ju		/fara:ʃah/	[fara:sah]	Butterfly
Ta		/ri:ʃ/	[li:s]	Feather
Da		/ʃams/	[s̰̃ams̰̃]	Sun
AG		/ʃa:hi/	[sa:hi]	Tea
Di		/ʃam.ʕah/	[sam.ʕah]	Candle
Mea		/fara:ʃah/	[fara:sah]	Butterfly
Os		/ʃʊma:ʁ/	[sʊma:g]	Saudi uniform

Table 7-39 Examples of velar fronting (cleft group)

Child initial	Examples	Adult's form	Child's form	Translation
Mon		/galam/	[dalam^h]	Pen
Ta		/sɪk.ki:nah/	[sɪt.ti:nah	Knife

Table 7-40 Examples of velar fronting (control group)

Child initial	Example	Adult's form	Child's form	Translation
Child W		/ʃɛma:ʁ/	[sɛma:ʁ]	Saudi uniform

7.8.8 Gliding of /r/

In this section, realisations of a trill as a glide are considered rather than the ways in which gliding is usually defined i.e. where liquids are realised as glides. In the cleft group, the process was evident in four children (see Table 7-41), who replaced the trill /r/ by the voiced labial velar approximant [w]. Examples of gliding for the cleft group are given in Table 7-42. Gliding was only used in the word-medial position rather than in the word-initial and word-final positions. Using this process was not consistent in any of the participants, as they sometimes produced /r/ accurately and sometimes substitute it with other consonants including [l,ʁ,ʔ,ɾ].

In the control group, none of the children used the process of gliding.

Table 7-41 Children presenting with gliding

	Child Initial	Gliding	
Cleft group	AG	/r/→[w]	WM
	Ju	/r/→[w]	WM
	Mis	/r/→[w]	WM
	Saa	/r/→[w]	WM
Control group	---	----	

Table 7-42 Examples of gliding (cleft group)

Child initial		Adult's form	Child's form	Translation
Ju	**Examples**	/χaruːf/	[χawũːf]	Sheep
AG		/χaruːf/	[χawuːf]	Sheep
Mis		/naðˤ.ðˤaːrah/	[naðˤ.ðˤaːwah]	Eyeglasses
Sa		/sɪj.jaːrah/	[θɪj.jãːwaːh]	Car

7.8.9 Lateralisation of /r/

Lateralisation of /r/ is evident in many studies of Arabic children (e.g. Saleh *et al*., 2007; Al-Awaji, 2008; Bader, 2009). In the current study, six children with cleft palate show the usage of this process where they substituted the trill /r/ by a voiced alveolar lateral approximant. This was more frequent and consistent in two children (Child Ta and Child Mu). Generally throughout the data of the cleft group, it was noticed that the sound/ r/ is frequently and inconsistently replaced by [ʁ,ɾ,rˠ,l,ʟ], all of which are either acceptable adult variants or found in normal phonological development. While English speaking children tend to use [w] for /r/, children learning languages which contain alveolar trills, such as Arabic and Italian, tend to substitute [l] for /r/ (Smith, 1973 ,So and Dodd,1994; Saleh *et al*., 2007). Table 7-43 shows examples of lateral realisations of /r/.

For the control group, Child A was the only child who frequently using lateral realisations for the trill /r/ (examples are given in Table 7-44).

Table 7-43 Children presenting with lateralisation of / r/

	Child Initial	**Lateralisation of /r/**	
Cleft group	AG	/r/→[l]	WM
	Ju	/r/→[l]	WM
	Ma	/r/→[l]	WM
	Mu	/r/→[l]	WI WM WF
	Os	/r/→[l]	WM
	Ta	/r/→[l]	WI WM WF
		/r/→[l]	WI WM WF
Control group	Child A	/r/→[l]	WI WM WF

Table 7-44 Examples of lateralisation of / r/ (cleft group)

Child initial	**Examples**	**Adult's form**	**Child's form**	**Translation**
Mu		/qɪ**r**d/	[gɪ**l**d]	Monkey
Ju		/fa**r**a:w.lah/	[fa**l**a:w.lah]	Strawberry
Ta		/**r**ɛdʒ.dʒa:l/	[**l**ɛz.za:l	Man
AG		/qɪ**r**d/	[qɛ**l**d]	Monkey
Os		/dʒa**r**as/	[da**l**as]	Bell
Ma		/χa**r**u:f/	[χa**l**ɔf]	Sheep

Table 7-45 Examples of lateralisation of / r/ (control group)

Child initial		Adult’s form	Child’s form	Translation
Child A	Examples	/naðˤ.ðˤaːrah/ /daːʔɪrah/	[naðˤ.ðˤaːlah] [daːʔɪlah]	Eyeglasses Circle

7.8.10 Context sensitive voicing and devoicing

Context-sensitive voicing typically involves using either voiced consonants as a substitution for voiceless ones pre-vocalically (first category) or unvoiced consonants for voiced consonants post-vocalically or before a pause (second category) (Grunwell, 1982).

For the cleft group, almost all pre-vocalic context-sensitive voicing of voiceless targets, occurred for stops (Table 7-46). There was a multiple occurrence of post-vocalic voicing of a voiceless fricative in the word /mʊf.taːħ/→[mʊv.taːħ], which is an unusual realisation for this context, but may have been influenced by the following syllable initial voiceless segment. Table 7-47 shows examples of the voicing process presented in five children. None of the children in the control group used the process of voicing.

For the second category (Table 7-48), the process occurs infrequently throughout the data in which only one child from the cleft group (see Table 7-49) used it only in one occasion in his speech and one child from the control group used it once (see Table 7-50) .

Table 7-46 Children presenting with context sensitive voicing

	Child Initial	context voicing sensitive	
Cleft group	Gh	/tˤ/→ [dˤ]	WM
	Jo	/k/→[g]	WM
	Me	/k/→[g]	WM
	Sa	/tˤ/→ [dˤ]	WM

	Ta	/f/→[v] /t/→ [d] /tˤ/→ [d]	WM WI WM WM WF

Table 7-47 Examples of context sensitive voicing (cleft group)

Child initial	Examples	Adult's form	Child's form	Translation
Ta		/tʊf.faːħ/	[dʊf.fɛːħ]	Apple
Gh		/matˤ.baχ/	[mɛdˤ.bɛχ]	Kitchen
Me		/dʊk.tuːræh/	[dag.tuːrah]	Doctor
Jo		/dak.tɔrah/	[dag.tɔrah]	Doctor
Sa		/matˤær/	[mædˤær]	Rain

Table 7-48 Children presenting with context sensitive voicing

	Child Initial	context devoicing sensitive
Cleft group	AG	/ʁ/→ [χ]
Control group	Child M	/ʁ/→ [χ]

Table 7-49 Examples of context sensitive devoicing (cleft group)

Child initial	Examples	Adult's form	Child's form	Translation
AG		/ʃʊmaːʁ/	[θʊmaːx]	Saudi uniform

Table 7-50 Examples of context sensitive devoicing (control group)

Child initial	Examples	Adult's form	Child's form	Translation
Child M		/ʃʊmaːʁ/	[ʃʊmaːx]	Saudi uniform

7.9 Structural processes affecting children with cleft palate

In this section, structural processes (see Table 7-51) found in the speech of the participants will be described in detail. Structural processes occurred rarely in the data, only two being observed: final consonant deletion and assimilation process/consonant harmony.

Table 7-51 Number and percentage of children with cleft palate using structural processes

Structural process	**Cleft group**		**Control group**	
	(*n*=21)	**%**	**(*n*=4)**	**%**
Final consonant deletion	18	85.7%	1	25%
Assimilation process/consonant harmony	9	42.8%	2	50%

7.9.1 Final consonant deletion

Final consonant deletion has been noted in the literature as a cleft speech feature (Chapman and Hardin, 1992; Harding and Grunwell, 1995), in other developmental speech disorders (Ingram, 1976) and also occurs as a normal phonological development (Stoel-Gammon and Dunn, 1985; Dodd, 1995; Bankson and Bernthal, 1998). Such deleted consonants have been frequently reported for back sounds i.e. target velar, uvular and pharyngeal consonants. The label 'Final consonant deletion' adopts the perspective of the speaker, implying that the child omits or deletes consonants in word-final position. However, in reality the categorisation is made by the listener (the transcriber /researcher or therapist), the evidence being that the target final segment is perceptually undetected.

As revealed in the table (Table 7-52), almost all children with cleft palate presented with final consonant deletion. One factor might be that syllables in word-final position are usually produced unstressed when compared with other word positions (i.e. personal suggestion). Although most of the deleted segments are plosives and fricatives, the children deleted a great range of targets, also including affricate, trills and nasals. It is important to note that glottal sounds /ʔ, h/ are usually omitted by Arabic speakers in the word-final position, thus the consonant is replaced by a vowel, turning the rhyme of the final syllable into a long monophthong.

Table 7-52 Children presenting with final consonant deletion

	Child Initial	Final consonant deletion	
Cleft group	**AG**	/tˤ/	WF
	AM	/n, r, dˤ/ /t /	WF WF
	Da	/m/	WF
	Gh	/m, f ,ʁ/	WF
	Jo	/d /	WF
	Ju	/d/	WF
	Ma	/d, r/	WF
		/d, ʃ/	WF
	Me	/ð,f, t ,d, dʒ,dˤ,k,ʁ ,χ, q /	WF
		/ ð,t ,dʒ , dˤ,tˤ q/	WF
	Mis	/r, q/	WF
	Moh	/dʒ/	WF
	Mon	/ ð,d , r , tˤ , q/	WF
		/ s ,tˤ/	WF
	Mu	/ʕ/	WF
		/ k/	WF
	Nas	/ t ,d , t ˤ/	WF
		/d , s, r, , t ˤ/	WF
	Os	/q/	WF
	Re	/d/	WF
	Sa	/f, t ,d , r /	WF
		/ θ,ð,/	WF
	Sau	/f ,d /	WF
		/tˤ/	WF
	Sh	/m, f, t , r , tˤ/	WF
		/ð,t , ,dˤ, tˤ/	WF
Control group	**Child A**	/ʕ,r/	WF

In the control group, deletion of the final consonant was the only reported structural process, and was used only by Child A: she deleted the final segment in two target words: /ʔaχ.dˤar/ ‘green’ and /dˤɪf.daʕ/ ‘frog’.

Thus, it can be suggested that the frequent occurrence of final consonant deletion in the cleft group in comparison with the control group might be due to a loss of intra-oral pressure which leads to unproduced consonants at the end of the words. It can also be related to a problem in their hearing/ perception of these final consonants which might be related to a history of recurrent middle ear effusion.

7.9.2 Assimilation/consonant harmony

Assimilation process occurs when a segment becomes similar or identical to an adjacent consonant and therefore both consonants become more alike. Assimilation can also occur across syllables or words. For the latter assimilation, Grunwell (1987: p.215) calls it as consonant harmony or “*assimilation at a distance*”. Such structural simplification is a normal pattern in the speech of younger children, but should not persist in typically developing children after the age of three (Grunwell, 1982).

As shown in Table 7-53, the process was used by nine children from the cleft group. Some of the assimilation processes could be interpreted as palato-alveolar fronting (e.g. /ʃams/→[sams]) as in the case of two children (Child Os [sams], Child Da [s̰̃ams̰̃]). With regard to Child Da the process would still be considered asassimilation as the child is able to produce the postalveolar fricative in other words and other positions of the word. On the other hand, Child Os’s production of that word is better considered as fronting rather than assimilation, as he substitutes all target /ʃ/ by [s]. Table 7-54 shows examples of assimilation process found in the data.

In the control group, assimilation was produced by Child M in only one target word /ʃams/ →[ʃamʃ] (i.e. progressive assimilation) along with Child W in the same target word/ʃams/ → [sams] (i.e. regressive assimilation).

Table 7-53Children presenting with assimilation

	Child Initial	Assimilation
Cleft group	AG	Velar, uvular,
	Da	Alveolar
	Di	Labiodental
	Ma	Alveolar
	Me	Postalveolar
	Mon	Postalveolar
	Mu	Alveolar ,labiodental, velar
	Os	Alveolar
	Ta	Alveolar
Control group	Child M	Postalveolar
	Child W	Alveolar

Table 7-53 Examples of assimilation (cleft group)

Child initial		Adult's form	Child's form	Translation
Mon	**Examples**	/ʃams/	[ʃamʃ]	Sun
Mu		/ʔar.nab/	[ʔañ.ñab]	Rabbit
Ta		/dʊk.tɔrah/	[dʊt.tɔlah]	Doctor
Da		/ʃams/	[s̃̃ams̃̃]	Sun
AG		/ʕɪtˤɪr/	[ʕɪqɪq]	Perfume
Di		/ðˤʊf.daʕ/	[ðˤʊf.faʕ]	Frog
Me		/dʒazar/	[ʒaʒã(r)]	Carrot
Os		/ʔar.nab/	[ʔan.napˈ]	Rabbit
Ma		/ʔar.nab/	[ʔan̥.ŋab]	Rabbit

7.10 Conclusion

In the first part of this chapter, two questions have been addressed and summarised in light of the results. The wider implications of the findings will be addressed in the Discussion chapter.

1. ***What are the speech development patterns found in typically developing children and children with cleft palate in Arabic?***

Apart from the reported cleft speech features, typical and/or developmental phonological processes have been reported (i.e. for the cleft group as well as for the control group in the second part of this chapter). There is evidence for the occurrence of systemic as well as structural developmental processes affecting children with cleft palate. The reported systemic processes include stopping, non-cleft dentalisation, de-pharyngealisation, de-affrication, affrication, non-cleft pharyngeal backing, postalveolar and /or velar fronting, gliding, assimilation, lateralisation and context sensitive voicing. Structural processes occurred only rarely in the data where the only reported processes include initial cluster reduction, initial cluster deletion and glottal insertion. When comparing the systemic process in the cleft group and the control group, the latter group had systemic processes including non-cleft dentalisation, stopping, de-pharyngealisation, de-affrication, non-cleft pharyngeal backing, postalveolar fronting, assimilation and lateral articulation. For the structural process, only one process occurred once for one of the children, that is, final consonant deletion.

2. ***What are the cleft speech features found in the speech of the Arabic children with cleft palate and how they are related to findings in other languages?***

The presentation of the results in the first part of this chapter was based on the design of GOS.SP.ASS cleft speech features. For the first question of this study concerned with cleft palate characteristics for Arabic children, all of the cleft speech features listed and reported in the GOS.SP.ASS have been noticed among the participants. These include problems affecting resonance (i.e. hypernasality and hyponasality), nasal emission, nasal turbulence and most of the GOS.SP.ASS cleft palate speech characteristics (CSCs) except for pharyngeal articulation, gliding of fricatives and affricate: none of the children used these three processes. Additional speech behaviour has been suggested to be included as a CSC, which is velopharyngeal fricative.

The implications of these results will be discussed further in Chapter 10.

Chapter 8 **Results of the Main Study - Descriptive Analysis**

8.1 Introduction

While Chapter 7 addressed the phonetic and phonological analysis undertaken on the data from the cleft palate and control groups, this chapter is concerned with descriptive analysis for the 21 children with cleft palate who participated in this study. Results are described in order to test predictions of pattern of segmental productions in each word position (word-initial, word-medial and word- final positions).

8.2 Hypotheses

To address Research Question 2 in Chapter 5 (what are the cleft speech characteristics found in the speech of the Arabic children with cleft palate and how they are related to findings in other languages? Are there any patterns which have not previously been reported in the literature?), the following specific hypotheses were tested:

1. Consonants in word-medial position are more accurately produced than consonants in word-initial and word-final positions.
2. In general, fricatives and plosives produced by the body of the tongue (i.e. /χ,ʁ,ħ,ʕ/) are more accurate than those produced by the blade of the tongue (i.e. /t, d, tˤ, dˤ, s, z, sˤ, ʃ, dʒ/) (e.g. Harding and Grunwell, 1996; Gibbon ,2004;Sell *et al*., 1999; Mekonnen ,2013).
3. Fricatives are the least accurately produced manner of articulation in cleft palate speech (e.g. Watson *et al*., 2001; Peterson-Falzone *et al*., 2006).

4. Alveolars (i.e. /t, d , $t^ʕ$, $d^ʕ$, s , z, $s^ʕ$, n, l, r/) and postalveolars (i.e. /ʃ, dʒ/) are the least accurately produced places of articulation in cleft palate speech (i.e. compared with bilabial, labiodental, palatal, velar, uvular, pharyngeal, and glottal) (e.g. Harding and Grunwell, 1993; Brøndsted, *et al*., 1994; Al-Tamimi *et al*., 2011).
5. Pharyngeals and glottals are the most accurately produced place of articulation in cleft palate speech. This because these sounds are commonly used by children with cleft palate as replacements for pressure consonants (Peterson-Falzone, 1989; Trost-Cardamone, 1990; Sell, 1994).
6. Voiced segments are more affected than voiceless segments in children with cleft palate (Harding and Grunwell, 1998).
7. Accuracy of segmental production is inversely correlated with age at assessment (e.g. Lohmander *et al*., 2011) and age at repair (e.g. Hardin-Jones and Jones, 2005; Chapman *et al*., 2008).
8. Bilateral Cleft Lip and Palate (BCLP) has the most severe effect on the accuracy production of consonantal segments (e.g. Karling *et al*., 1993; Hardin-Jones and Jones, 2005).

To test the above hypotheses, children's consonantal segment production were analysed in each word position and the following points were addressed and reported separately for each position:

- The most and least accurate consonantal segments.
- The accuracy of consonant production was evaluated in relation to different manners and places of articulation.
- The accuracy of consonant production was evaluated in relation to voiced versus voiceless consonants.
- The accuracy of consonant productions was compared in relation to two different variables: age at repair and type of cleft palate.

8.3 Word-initial position

For the 21 children in the sample, the mean percentage of total segmental accuracy in word-initial position has been calculated for all children with cleft palate (Table 8-1). Taking the segment /b/ as an example, child AG produced it to an accuracy of 100% (i.e. achieved a score of 5 out of 5), whereas child Di produced the same segment at a rate of 60% accuracy (i.e. achieved a score of 3 out of 5). The same table (Table 8-1) also shows the overall mean percentage of accurate realisations for each target for all the children. For example, looking across all productions by all children, /**b**/ had an overall segmental accuracy of 80%. (See Appendix 6 for percentage of segmental production accuracy for all consonants in word-initial position).

8.3.1 Most and least accurate segments (word-initial position)

Table 8-2 represents a summary of the same data obtained from Table (8-1); that is, Table 8-2 gives direct information on the number of children who produced accurate consonantal segments based on the quantile classification method in which each category contains the same number of features. Thus, four categories are included which are 0%-24%, 25%-49%, 50%-74%, and 75%-100%.The categories describe the following:

- The (75%-100%) category involves the number of children who produced the segments with a level of accuracy between 75% and 100%
- The (50%-74%) category involves the number of children who produced the segments with a level of accuracy between 50% and 74%
- The (25% to 49%) category involves the number of children who produced the segments with a level of accuracy between 25% and 49%

- The (0% to 24%) category involves the number of children who produced the segments with a level of accuracy between 0% and 24%

8.3.2 Most accurate consonantal segments (word-initial position)

The most accurate consonantal segments are identified based on how many children produced the segment with a level of accuracy of between 75% and 100%. As can be seen in Table 8-2, the most accurate segments produced are nasals /m, n/, the pharyngeal /ʕ/, the glottal stop /ʔ/, and the voiceless glottal fricative /h/ as well as the labial-velar glide /w/; all or almost all of the children produced these accurately (*n*= 20 or 21). In Table 8-3, a list is given for all of the segments produced by 10 or more children within the 75%-100% range, arranged from highest to lowest level of accuracy.

8.3.3 Least accurate consonantal segments (word-initial position)

From Table 8-2, the least accurate segments can also be identified, within the category of 0%-24%; where 0% means that the segment was not produced at all. The least accurately produced segment is the emphatic /sˤ/ which was only accurately produced by five children. Table 8-3 lists the least accurate segments produced by 10 or more children (i.e. organised from least accurate segment to most accurate). The second least accurately produced segment is the voiced alveolar fricative /z/ which was only produced accurately by seven children, followed by the voiceless alveolar fricative and the voiceless postalveolar fricative produced accurately by twelve children. These are all tongue-blade fricatives.

Table 8-1 Mean percentage of total segmental accuracy in word-initial position for all children with cleft palate

Child initial	Mean [a]
AG	86.4
AM	71.0
Da	75.6
Di	80.9
Gh	82.0
Jo	87.4
Ju	83.9
Ma	71.2
Me	65.7
Mis	92.0
Moh	85.2
Mon	60.7
Mu	64.1
Nah	82.0
Nas	32.8
Os	78.2
Re	87.2
Sa	58.9
Sau	37.1
Sh	56.0
Ta	46.6
Mean [b]	**71.0**

a. Mean segmental accuracy percentage for each child
b. Mean segmental accuracy percentage for all children in word-initial position

Table 8-2 Number of children who produced accurate realisations of individual word-initial consonant segments based on four categories of percentage segmental accuracy

Consonants / (%) a	0 -24%		25-49%		50-74%		75-100%	
	n	%	*n*	%	*n*	%	*n*	%
b	2	9.5	2	9.5	2	9.5	15	71.4
t	9	42.8	0	0.0	0	0.0	12	75.1
d	3	14.2	0	0.0	2	9.5	16	76.2
k	4	19.0	1	4.7	3	14.2	13	61.9
q	4	19.0	1	4.7	1	4.7	15	71.4
tˤ	8	38.0	0	0.0	0	0.0	13	61.9
dˤ	11	52.4	0	0.0	2	9.5	8	38.0
ʔ	0	0.0	0	0.0	0	0.0	21	100
f	3	14.2	2	9.5	0	0.0	16	76.2
θ	6	28.6	0	0.0	0	0.0	15	71.4
ð	6	28.6	0	0.0	0	0.0	15	71.4
s	12	75.1	2	9.5	2	9.5	5	23.8
z	14	66.6	0	0.0	0	0.0	7	33.3
ʃ	12	75.1	3	14.2	0	0.0	6	28.6
sˤ	16	76.2	2	9.5	3	14.2	0	0.0
ðˤ	5	23.8	1	4.7	2	9.5	14	66.6
χ	2	9.5	0	0.0	0	0.0	19	90.5
ʁ	4	19.0	0	0.0	0	0.0	17	81.0
ħ	0	0.0	2	9.5	5	23.8	14	66.6
ʕ	0	0.0	1	4.7	0	0.0	20	95.2
h	0	0.0	0	0.0	0	0.0	21	100.0
dʒ	10	47.6	3	14.2	0	0.0	8	38.1
m	0	0.0	0	0.0	1	4.7	20	95.2
n	0	0.0	0	0.0	1	4.7	20	95.2
r	4	19.0	0	0.0	2	9.5	15	71.4
w	0	0.0	0	0.0	0	0.0	21	100.0
l	2	9.5	0	0.0	2	9.5	17	81.0
j	4	19.0	0	0.0	0	0.0	17	81.0

Table 8-3 Most and least accurate word-initial segments produced by10 or more children

Most accurate segments produced within the range of 75-100% accuracy		Least accurate segments produced within the range of 0-24% accuracy	
Segments	**Number of children (%)**	**Segments**	**Number of children (%)**
ʔ	21(100%)	sˤ	16 (76.2%)
h	21 (100%)	z	14 (66.6%)
w	21 (100%)	s	12 (57.1%)
m	20 (95.2%)	ʃ	12 (57.1%)
n	20 (95.2%)	dˤ	11 (52.4%)
χ	19 (90.5%)	dʒ	10 (47.6%)
ʁ	17 (81.0%)	sˤ	16 (76.2%)
l	17 (81.0%)	z	14 (66.6%)
j	17 (81.0%)	s	12 (57.1%)
d	16 (76.2%)	ʃ	12 (57.1%)
f	16 (76.2%)	dˤ	11 (52.4%)
b	15 (71.4%)	dʒ	10 (47.6%)
q	15 (71.4%)		
θ	15 (71.4%)		
ð	15 (71.4%)		
r	15 (71.4%)		
ðˤ	14 (66.6%)		
ħ	14 (66.6%)		
k	13 (61.9%)		
t	12 (57.1%)		

8.3.4 Percentage accuracy: manner of articulation (word-initial position)

The percentage of accuracy of each manner of articulation for all children with cleft palate is given in Table 8-4. The highest accurately produced manner of articulation is nasals at a 94% level of accuracy. This is followed by liquids/glides which were produced at an 85.7% level of accuracy. Plosives are the third most accurately produced manner of articulation, at 75.8%, followed by fricatives at 60.9%, and finally by affricate at 41%. In Table 8-5, manners of articulations are ranked, from the highest to the lowest.

When evaluating the percentage achieved by each individual child in each manner of articulation, however, there are noticeable differences between the children. For example, although the affricate is the most difficult manner of articulation across the entire group of participants, four children produced it accurately (100%), compared with nine children who could not produce it at all (0%). Furthermore, nasal is the most accurately produced manner of articulation; however, child Sau produced it at a level of only 67% accuracy, whereas the rest of the children produced nasals with accuracy levels the range of 80% or more

8.3.5 Percentage accuracy: place of articulation (word-initial position)

Before describing the result of this section, it is important to remember that (as described in Chapter 1, Section 1.3) there are two classes of coronal consonants which are: non-emphatic (/s , d, t , ð/), and emphatic (/$s^ʕ$, $d^ʕ$, $t^ʕ$, $ð^ʕ$/). Emphatics have a primary (i.e. dental and alveolar) place of articulation and are distinguished from their non-emphatic cognates by the presence of a secondary articulation (pharyngealisation). From this section onwards (section 8.4.5, section 8.5.5 and Tables 8-6, 8-7, 8-15, 8-16, 8-24, 8-25), emphatics are listed separately in order to compare which group of sounds (emphatics vs. non-emphatics) are more accurately produced than the other.

Table 8-6 illustrates the percentage of accuracy of each place of articulation. Pharyngeals and glottals were the most accurate places of articulation which were produced at levels of 91% and 98% accuracy respectively by all children (*n*=21). These are followed by the labial place of articulation which was correctly produced by all children 88% of the time; followed, respectively, by the single palatal /j/ (81%), uvular (77%), velar (73%) and then alveolar consonants (66%). As shown in the table, the least accurate place of articulation is postalveolar (38%) followed by emphatics, where 41% of the segments were produced accurately by all children. In Table 8-7, places of articulations are ranked; from the highest to the lowest.

Again, significant inter-speaker variation was been noted. For instance, child Nah produced uvulars accurately (100%), whereas child Ta and child Sau never realise uvulars accurately at all (0%). Table 8-7 presents the minimum, maximum and mean percentages for each place of articulation.

Table 8-4 Percentage of accuracy of each manner of articulation in word-initial position for all children with cleft palate

Manner / Child	**Plosives**	**Fricatives**	**Affricate**	**Nasals**	**Liquids/ Glides**
AG	88.0	70.6	100	100.0	100.0
AM	84.0	58.8	0.0	86.7	87.5
Da	80.0	82.4	0.0	93.3	100.0
Di	92.0	61.8	0.0	100.0	100.0
Gh	92.0	64.7	100	100.0	100.0
Jo	84.0	85.3	20	93.3	100.0
Ju	96.0	67.6	40	100.0	62.5
Ma	88.0	70.6	40	93.3	75.0
Me	60.0	50.0	80	100.0	100.0
Mis	84.0	91.2	100	93.3	100.0
Moh	96.0	76.5	100	100.0	100.0
Mon	52.0	64.7	80	86.7	87.5
Mu	72.0	44.1	40	100.0	87.5
Nah	100.0	52.9	80	100.0	100.0
Nas	16.0	35.3	0.0	86.7	37.5
Os	88.0	70.6	0.0	80.0	100.0
Re	96.0	82.4	80	100.0	87.5
Sa	76.0	44.1	0.0	100.0	75.0
Sau	28.0	29.4	0.0	66.7	50.0
Sh	64.0	38.2	0.0	100.0	87.5
Ta	56.0	38.2	0.0	93.3	62.5
Mean [a]	**75.8**	**60.9**	**41.0**	**94.0**	**85.7**

a. Mean segmental accuracy percentage for all children (*n*=21) in each manner of articulation

Table 8-5 Minimum, Maximum and Mean percentages of accurate word-initial segments in each manner of articulation

Variables	Mean	Minimum	Maximum
1. Nasals	93.97	67	100
2. Liquids/Glides	85.71	38	100
3. Plosives	75.81	16	100
4. Fricatives	60.92	29	91
5. Affricate[12]	40.95	0	100

*Manners of articulations are ranked depend on the mean (from the highest to the lowest)

[12]Here and everywhere in this chapter, Affricate is written as singular rather than plural as Arabic phonetic inventory has only one affricate /dʒ/ .

Table 8-6 Percentage of word-initial segmental accuracy for all children with cleft palate based on place of articulation

Child \ Place[a]	Labial	Dental	Alveolar	Post-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal	Emphatic[13]
AG	100.0	100.0	94.4	54.5	100.0	100.0	100.0	83.3	50.0	37.5
AM	90.5	100.0	72.2	9.1	0.0	100.0	77.8	83.3	100.0	37.5
Da	95.2	50.0	83.3	45.5	100.0	100.0	88.9	100.0	100.0	37.5
Di	90.5	100.0	83.3	0.0	100.0	100.0	88.9	100.0	100.0	62.5
Gh	95.2	100.0	77.8	63.6	100.0	100.0	88.9	100.0	100.0	50.0
Jo	90.5	100.0	72.2	63.6	100.0	100.0	100.0	100.0	100.0	62.5
Ju	100.0	100.0	61.1	36.4	100.0	100.0	100.0	83.3	100.0	62.5
Ma	100.0	100.0	44.4	72.7	100.0	66.7	88.9	83.3	100.0	62.5
Me	81.0	100.0	66.7	36.4	100.0	0.0	55.6	100.0	100.0	50.0
Mis	95.2	100.0	88.9	100.0	100.0	100.0	77.8	100.0	100.0	62.5
Moh	100.0	100.0	66.7	100.0	100.0	100.0	100.0	100.0	100.0	62.5
Mon	76.2	50.0	66.7	54.5	0.0	66.7	55.6	100.0	100.0	37.5
Mu	90.5	50.0	50.0	27.3	0.0	66.7	88.9	100.0	100.0	12.5
Nah	100.0	100.0	72.2	36.4	100.0	100.0	100.0	66.7	100.0	62.5
Nas	52.4	0.0	11.1	0.0	100.0	0.0	44.4	100.0	100.0	0.0
Os	85.7	50.0	88.9	0.0	100.0	100.0	100.0	100.0	100.0	50.0
Re	100.0	50.0	83.3	90.9	100.0	100.0	88.9	100.0	100.0	62.5
Sa	100.0	50.0	55.6	0.0	0.0	33.3	88.9	83.3	100.0	12.5
Sau	47.6	50.0	22.2	0.0	100.0	0.0	0.0	100.0	100.0	12.5
Sh	66.7	0.0	50.0	0.0	100.0	100.0	88.9	100.0	100.0	25.0
Ta	95.2	50.0	77.8	0.0	100.0	0.0	0.0	33.3	100.0	0.0
Mean[b]	**88.2**	**71.4**	**66.1**	**37.7**	**81.0**	**73.0**	**77.2**	**91.3**	**97.6**	**41.1**

a. Mean segmental accuracy percentage for all children (*n*=21) in each manner of articulation

[13] Emphatics (/sˤ , dˤ, tˤ , ðˤ/) are included in the table as they share the same secondary articulatory feature but have different places of articulations

Table 8-7 Minimum, Maximum and Mean percentages for accurate word-initial segments in each place of articulation

Variables	Mean	Minimum	Maximum
1. Glottal	97.62	50	100
2. Pharyngeal	91.19	33	100
3. Labial	88.10	48	100
4. Palatal	80.95	0	100
5. Uvular	77.33	0	100
6. Velar	73.05	0	100
7. Dental	71.43	0	100
8. Alveolar	66.10	11	94
9. Emphatics[14]	41.43	0	63
10. Post-Alveolar	37.67	0	100

*Places of articulations are ranked according to the mean (from the highest to the lowest)

[14] Emphatics (/sˤ , dˤ, tˤ , ðˤ/) are included in the table as they share the same secondary articulatory feature but have different places of articulations

8. 3.6 Percentage of voiced versus voiceless word-initial segmental production accuracy

8.3.6.1 Voiced segmental accuracy (word-initial position)

In the current study, voiced versus voiceless segmental accuracy refers to the accuracy of the voicing feature (i.e. vibration of the vocal folds).

As shown in Table 8-8, the average percentage of all voiced segmental accuracy levels produced by all children was 91.8%. In terms of the accuracy in each segment, the results reveal that the alveolar /z/ is the most affected voiced segment (81.0%), followed by the emphatic /dˤ/ affricate (83.3%), followed by /ð/ and /j/ (85.7%), whereas bilabials /b,m/, alveolar /n/, liquid /l/ and pharyngeal /ʕ/ were least difficult voiced segments to produce, with an average percentage of more than 96%. The ability to produce voiced consonants accurately differs considerably from one child to another. For example, child Re had an average percentage of 100% for voiced segmental accuracy; while child Nas had an average of 46.5%.

8.3.6.2 Voiceless segmental accuracy (word-initial position)

The average percentage of all voiceless segmental accuracy in all children is 93.2% (Table 8-9). In terms of the individual voiceless segments, the results reveal that glottals /h,ʔ/ and the pharyngeal /ħ/ have the highest percentage of voiceless segmental accuracy (100%), followed by uvular (97.6%) and then dental /θ/and the emphatic /tˤ/ (95.2%). In contrast, the least accurate segment is the uvular /q/ which was produced at a level of only 80.6% by all children, followed by the alveolar /t/, at 85.7%.

When viewing the children’s performance on voiceless segments, results reveal that most of the children had a percentage of more than 90%. On the other hand, considerable individual variation in terms of the ability to produce voiceless consonants accurately; for example, child Sau and child Sh could only produce 54.7% and 61.5% respectively of the voiceless consonants accurately.

Table 8-8 Percentage of voiced word-initial segmental accuracy for all children with cleft palate

Voiced Init. / Child	b(5)[15]	m(13)	ð(1)	d(5)	n(2)	r(3)	z(1)	dʒ(5)	j(1)	l(2)	ʁ(1)	ʕ(3)	dˤ(2)	ðˤ(2)	Mean [a]
AG	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AM	100.0	84.6	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	100.0	91.8
Da	100.0	92.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5
Di	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gh	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Jo	80.0	92.3	100.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.6
Ju	100.0	100.0	100.0	100.0	100.0	33.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.2
Ma	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Me	80.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.6
Mis	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[15] Here and everywhere in this chapter, number between brackets indicates number of tokens for the target sound in each word position, e.g. b (5).

Moh	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	92.9
Mon	100.0	76.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	91.2
Mu	100.0	100.0	0.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	78.6
Nah	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nas	100.0	84.6	0.0	0.0	100.0	66.6	0.0	0.0	100.0	100.0	0.0	100.0	0.0	0.0	46.5
Os	100.0	76.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.3
Re	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sa	100.0	100.0	100.0	100.0	100.0	66.6	100.0	100.0	0.0	100.0	100.0	100.0	100.0	100.0	90.5
Sau	100.0	84.6	0.0	100.0	100.0	66.6	0.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0	80.8
Sh	80.0	100.0	100.0	100.0	100.0	66.6	0.0	60.0	100.0	100.0	100.0	100.0	50.0	100.0	82.6
Ta	100.0	100.0	100.0	100.0	100.0	100.0	100.0	60.0	100.0	100.0	0.0	33.3	100.0	100.0	85.2
Mean[b]	97.1	94.8	85.7	94.3	100.0	90.5	81.0	90.5	85.7	100.0	90.5	96.8	83.3	95.2	91.8

a.Mean voiced segmental accuracy percentage or each child, b. Mean segmental accuracy percentage for each voiced consonant

Table 8-9 Percentage of voiceless word-initial segmental accuracy for all children with cleft palate

Child Init. \ Voiceless	f(3)	θ(1)	t(1)	s(4)	ʃ(6)	k(3)	q(4)	χ(4)	ħ(3)	h(2)	ʔ (4)	sˤ(3)	tˤ(1)	Mean[a]
AG	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100
AM	100.0	100.0	100.0	100.0	100.0	100.0	25.0	100.0	100.0	100.0	100.0	100.0	100.0	94.2
Da	100.0	100.0	100.0	100.0	100.0	100.0	25.0	100.0	100.0	100.0	100.0	100.0	100.0	94.2
Di	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gh	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Jo	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ju	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ma	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Me	100.0	100.0	0.0	100.0	100.0	100.0	50.0	100.0	100.0	100.0	100.0	100.0	100.0	88.5
Mis	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Moh	100.0	100.0	100.0	75.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	66.6	100.0	95.5
Mon	100.0	100.0	100.0	100.0	100.0	66.6	50.0	100.0	100.0	100.0	100.0	100.0	100.0	93.6
Mu	66.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.4
Nah	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nas	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Os	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Re	100.0	100.0	100.0	100.0	100.0	100.0	50.0	100.0	100.0	100.0	100.0	100.0	100.0	96.2
Sa	100.0	100.0	100.0	100.0	100.0	100.0	100.0	50.0	100.0	100.0	100.0	100.0	100.0	96.2
Sau	33.3	100.0	100.0	50.0	0.0	0.0	25.0	100.0	100.0	100.0	100.0	0.0	0.0	54.5
Sh	0.0	0.0	0.0	0.0	33.3	100.0	100.0	100.0	100.0	100.0	100.0	66.6	100.0	61.5
Ta	100.0	100.0	0.0	100.0	100.0	33.3	66.6	100.0	100.0	100.0	100.0	100.0	100.0	84.6
Mean[b]	90.5	95.2	85.7	91.7	92.1	90.5	80.6	97.6	100.0	100.0	100.0	92.1	95.2	93.2

a. Mean voiceless segmental accuracy percentage or each child, b. Mean segmental accuracy percentage for each voiceless consonant

8.4 Word-medial position[16]

The structure of the word-medial position section is presented below in a similar way to the previous section on word-initial position.

8.4.1 Most and least accurate segments (word-medial position)

As with the analysis conducted on word-initial position, the mean percentage of total segmental production accuracy in word-medial position has been calculated for all children with cleft palate (see Table 8-10). (See Appendix 6 for percentage of segmental production accuracy for all consonants in word-medial position).

Additionally, a summary table was created specifically to obtain information on the number of children who produced accurate segments in the word-medial position based on four categories which are 0%-24%, 25%-49%, 50%-74%, and 75%-100%. These categories provide the same information explained earlier in the word-initial position section (8.3.1).

8.4.2 Most accurate consonantal segments (word-medial position)

Information on the most accurate segments is based on how many children produced the segment with a level of accuracy of between 75% and 100% (Table 8-11). As revealed from the table, the most accurate segments produced are the nasal /m/, the liquid /l/ , the uvular /q/, glottal /ʔ, h/, pharyngeals /ħ,ʕ/ and approximants /w, j/, where almost all of the children produced these accurately. The accuracy ranking of the rest of the segments produced by 10 children or more within the 75%-100% range, arranged from highest to lowest level of accuracy is given in Table 8-12.

[16]Internal target consonant that has either a vowel or consonant regardless of the syllable position

8.4.3 Least accurate consonantal segments (word-medial position)

The least accurately-produced segments are those in the category 0%-24%. As revealed from Table 8-12, the two least accurately produced segments are the emphatic /sˤ/ and the voiced alveolar fricative /z/, where only six children produced these accurately. These are followed by the voiceless alveolar fricative (produced accurately by seven children) and the postalveolar fricative (produced accurately by 11 children).

Table 8-10 Mean percentage of total segmental accuracy in word-medial position for all children with cleft palate

Child initial	Mean [a]
AG	83.0
AM	78.5
Da	80.6
Di	83.6
Gh	80.2
Jo	87.3
Ju	86.9
Ma	81.4
Me	68.5
Mis	91.4
Moh	91.4
Mon	67.0
Mu	69.2
Nah	77.6
Nas	48.4
Os	78.6
Re	95.5
Sa	77.7
Sau	36.8
Sh	51.7
Ta	63.5
Mean [b]	**75.2**

a. Mean segmental accuracy percentage for each child
b. Mean segmental accuracy percentage for all children in word-medial position

Table 8-11 Number of children who produced accurate realisation of individual word-medial consonant segments based on four categories of percentage segmental accuracy

Consonants / (%) [a]	0 -24%		25-49%		50-74%		75-100%	
	n	%	*n*	%	*n*	%	*n*	%
b	1	4.7	3	14.2	0	0.0	17	80.9
t	5	23.8	1	4.7	2	9.5	13	61.9
d	2	9.5	0	0.0	3	14.2	16	76.2
k	4	19.0	0	0.0	7	33.3	10	47.6
q	1	4.7	0	0.0	0	0.0	20	95.2
tˤ	7	33.3	3	14.2	1	4.7	10	47.6
dˤ	7	33.3	0	0.0	0	0.0	14	66.6
ʔ	0	0.0	0	0.0	0	0.0	21	100.0
f	2	9.5	2	9.5	2	9.5	15	71.4
θ	4	19.0	0	0.0	2	9.5	15	71.4
ð	3	14.2	0	0.0	0	0.0	18	85.7
s	8	38.1	3	14.2	3	14.2	7	33.3
z	14	66.6	0	0.0	0	0.0	7	33.3
ʃ	15	71.4	0	0.0	0	0.0	6	28.6
sˤ	15	71.4	0	0.0	6	28.6	0	0.0
ðˤ	2	9.5	0	0.0	2	9.5	17	80.9
χ	1	4.7	0	0.0	5	23.8	15	71.4
ʁ	10	47.6	0	0.0	0	0.0	11	52.3
ħ	0	0.0	0	0.0	0	0.0	21	100.0
ʕ	0	0.0	0	0.0	0	0.0	21	100.0
h	0	0.0	0	0.0	0	0.0	21	100.0
dʒ	7	33.3	3	14.2	2	9.5	9	42.8
m	0	0.0	0	0.0	1	4.7	20	95.2
n	0	0.0	0	0.0	3	14.2	18	85.7
r	3	14.2	0	0.0	6	28.6	12	75.1
w	0	0.0	0	0.0	0	0.0	21	100.0
l	1	4.7	0	0.0	0	0.0	20	95.2
j	0	0.0	0	0.0	0	0.0	21	100.0

Table 8-12 Most and least accurate word-medial segments produced by10 or more children

Most accurate segments produced within the range of 75-100% accuracy		Least accurate segments produced within the range of 0-24% accuracy	
Segments	**Number of children (%)**	**Segments**	**Number of children (%)**
ʔ	21 (100.0%)	**sˤ**	15(71.4%)
ħ	21(100.0%)	**z**	15 (71.4%)
ʕ	21(100.0%)	**s**	14 (66.6%)
h	21(100.0%)	**ʃ**	10 (47.6.1%)
m	20 (95.2%)		
l	20 (95.2%)		
ð	18 (85.7%)		
n	18 (85.7%)		
ðˤ	17 (80.9%)		
b	17 (80.9%)		
d	16 (76.2%)		
f	15 (71.4%)		
θ	15 (71.4%)		
χ	15 (71.4%)		
dˤ	14 (66.6%)		
t	13 (61.9%)		
r	12 (57.1%)		
ʁ	11(52.3%)		
k	10 (47.6%)		
tˤ	10 (47.6%)		

8.4.4 Percentage accuracy: manner of articulation (word-medial position)

Table 8-13 gives the percentage of accuracy of each manner of articulation in the word-medial position. As shown from the table, nasals are the most accurately produced manner of articulation as they were produced with 96% accuracy in the word-medial position. The second most accurately produced manner of articulation is liquids at 85% level of accuracy, followed by plosives at 74%, fricatives at 71% and finally affricate at 57%. In Table 8-14, manners of articulations are ranked from the highest to the lowest.

As is the case with the word-initial position, differences have been noticed between children. This is revealed in terms of the percentage achieved in each manner of articulation. For instance, despite the low percentage achieved by all children for the affricate, nine children produced it 100% accurately, in contrast to seven children who never produced it accurately (0%). (Table 8-13).

8.4.5 Percentage accuracy: place of articulation (word-medial position)

As shown in Table 8-15, the most accurate places of articulation are palatal (which involves only one segment /j/), pharyngeal and glottal, which were all produced at levels of 100% accuracy by all children (*n*=21). These were followed, respectively, by labial (85%), uvular (82%), dental (79%) and alveolar (78%). On the other hand, the least accurate place of articulation is postalveolar at 48%, followed by emphatics which were produced at a level of 53% by all children. In Table 8-16, place of articulations are ranked, from the highest to the lowest.

Large differences were also noticed between children. For instance, although postalveolar was the least accurately produced place for the group as a whole, child Jo produced it 100% accurately, whereas child Nas did not produce any postalveolar articulation accurately (0%).

Table 8-13 Percentage of accuracy of each manner of articulation in word-medial position for all children with cleft palate

Manner / Child	Plosives	Fricatives	Affricate	Nasals	Liquids
AG	81	84	100	100	86
AM	96	71	33	100	100
Da	81	87	0	100	94
Di	100	74	0	100	100
Gh	96	71	67	100	100
Jo	81	87	100	86	100
Ju	92	87	100	100	100
Ma	85	71	100	86	89
Me	58	55	33	100	100
Mis	100	90	100	100	78
Moh	100	81	100	93	92
Mon	35	65	100	100	86
Mu	77	61	33	86	78
Nah	96	71	100	86	100
Nas	19	32	0	100	50
Os	77	81	0	100	86
Re	92	97	100	100	97
Sa	77	71	67	100	75
Sau	12	26	0	93	25
Sh	35	42	0	93	86
Ta	62	68	0	100	50
Mean [a]	**74**	**71**	**57**	**96**	**85**

a. Mean segmental accuracy percentage for all children (*n*=21) in each manner of articulation

Table 8-14 Minimum, Maximum and Mean percentages of accurate word-medial segments in each manner of articulation

Variables		Mean	Minimum	Maximum
1.	Nasals	96.26	85.7	100.0
2.	Liquids/glides	84.39	25.0	100.0
3.	Plosives	73.8	11.5	100.0
4.	Fricatives	70.04	25.8	96.8
5.	Affricate	53.96	0.0	100.0

Manners of articulations are ranked according to the mean (from the highest to the lowest)

Table 8-15 Percentage of word-medial segmental accuracy for all children with cleft palate based on place of articulation

Child \ Place[a]	Labial	Dental	Alveolar	Post-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal	Emphatic[17]
AG	100	67	88	75	100	100	80	100	100	40
AM	95	100	92	25	100	50	80	100	100	80
Da	100	67	90	25	100	50	100	100	100	60
Di	85	100	96	0	100	100	100	100	100	80
Gh	100	100	90	50	100	100	80	100	100	70
Jo	100	100	88	100	100	50	100	100	100	60
Ju	100	100	98	75	100	50	80	100	100	80
Ma	90	100	77	100	100	0	100	100	100	70
Me	75	100	81	25	100	100	60	100	100	30
Mis	100	100	85	75	100	100	80	100	100	90
Moh	95	100	88	100	100	100	80	100	100	80
Mon	60	67	75	100	100	0	60	100	100	30
Mu	95	33	65	25	100	100	80	100	100	50
Nah	90	100	90	75	100	100	80	100	100	70
Nas	35	0	35	0	100	100	100	100	100	10
Os	90	100	87	0	100	100	100	100	100	30
Re	100	100	98	100	100	50	100	100	100	80
Sa	90	100	67	50	100	50	100	100	100	70
Sau	35	0	17	0	100	0	0	100	100	30
Sh	60	33	65	0	100	50	80	100	100	0
Ta	95	100	56	0	100	0	80	100	100	0
Mean[b]	**85**	**79**	**78**	**48**	**100**	**64**	**82**	**100**	**100**	**53**

a. Place of articulation
b. Mean segmental accuracy percentage for all children (n=21) in each place of articulation

[17] Emphatics (/sˤ , dˤ, tˤ , ðˤ/) are included in the table as they share the same secondary articulatory feature but have different places of articulations

Table 8-16 Minimum, Maximum and Mean percentages for accurate word-medial segments in each place of articulation

Variables	Mean	Minimum	Maximum
1. Palatal	100.0	100	100
2. Pharyngeal	100.0	100	100
3. Glottal	100.0	100	100
4. Labial	85.2	35	100
5. Uvular	81.90	0	100
6. Dental	79.3	0	100
7. Alveolar	77.5	17	98
8. Velar	64.29	0	100
9. Emphatics[18]	52.8	0	90
10. Post-Alveolar	47.6	0	100

*Places of articulations are ranked according to the mean (from the highest to the lowest)

[18] Emphatics (/sˤ , dˤ, tˤ , ðˤ/) are included in the table as they share the same secondary articulatory feature but have different places of articulations

8. 4.6 Percentage of voiced versus voiceless segmental production accuracy for word-medial consonants

8.4.6.1 Voiced segmental accuracy (word-medial position)

In general all of the voiced segments in word-medial position had a high percentage of segmental accuracy. The average percentage of all voiced segmental accuracy produced by all children was 96.0% (please refer to Table 8-17). For segmental accuracy, findings indicate that the alveolar /ð/ is the most affected voiced segment (90.5%). This is followed by the emphatic /ðˤ/ (92.9%) and nasal /n/ (93.2%) and then the alveolar /d/ (94.4%). On the other hand, palatal /j/, uvular /ʁ/ and pharyngeal /ʕ/ were the segments that the children did not experience any difficulty with: all of the latter segments have an average percentage of 100%.

8.4.6.2 Voiceless segmental accuracy (word-medial position)

The mean percentage of overall voiceless segmental accuracy in the word-medial position is 94.3% (Table 8-18). For each voiceless segment, results show that pharyngeals and glottals were produced 100% accurately, followed by the uvular at a 97.6% level of accuracy. On the other hand, the least accurate segment is the alveolar /s/ which was produced at a level of only 86.9% by all children, followed by the emphatic /tˤ/at 87.6% and finally the labiodental /f/, at 89.9%.

When evaluating each child's performance on voiceless segment accuracy, results show that nine children (i.e. AM, Da, Di, Ju, Ma, Mis, Nah, Nas, Re) achieved a percentage of 100% and 11 children achieved a level of segmental accuracy above 90%. On the other hand, only one child had a very low percentage, child Sau with 30.

Table 8-17 Percentage of voiced word-medial segmental accuracy for all children with cleft palate

Voiced / Child Init.	b(4)	m(7)	ð(1)	d(6)	n(7)	r(19)	z(1)	dʒ(3)	j(5)	l(10)	ʁ(1)	ʕ(2)	dˤ(1)	ðˤ(2)	Mean [a]
AG	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AM	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Da	100.0	100.0	100.0	83.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.8
Di	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gh	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Jo	100.0	100.0	100.0	100.0	71.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.0
Ju	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ma	100.0	100.0	100.0	100.0	71.4	94.7	100.0	100.0	100.0	90.0	100.0	100.0	100.0	100.0	96.9
Me	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mis	100.0	100.0	100.0	100.0	100.0	94.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6
Moh	100.0	100.0	100.0	100.0	100.0	94.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6
Mon	100.0	100.0	0.0	100.0	100.0	84.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	91.7
Mu	100.0	100.0	100.0	100.0	57.1	84.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.8

Nah	100.0	57.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.9
Nas	25.0	100.0	0.0	0.0	100.0	68.4	0.0	0.0	100.0	100.0	100.0	100.0	0.0	0.0	49.5
Os	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	50.0	96.4
Re	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sa	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sau	100.0	85.7	100.0	100.0	100.0	94.7	100.0	100.0	100.0	70.0	100.0	100.0	100.0	100.0	96.5
Sh	100.0	100.0	100.0	100.0	57.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.9
Ta	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mean[b]	96.4	97.3	90.5	94.4	93.2	96.0	95.2	95.2	100.0	98.1	100.0	100.0	95.2	92.9	96.0

a.Mean voiced segmental accuracy percentage or each child, b. Mean segmental accuracy percentage for each voiced consonant

Table 8-18 Percentage of voiceless word-medial segmental accuracy for all children with cleft palate

Voiceless / Child Init.	f(9)	θ(2)	t(5)	s(4)	ʃ(2)	k(2)	q(2)	χ(2)	ħ(2)	h(2)	ʔ (1)	sˤ(2)	tˤ(5)	Mean[a]
AG	100.0	100.0	100.0	100.0	100.0	100.0	100.0	50.0	100.0	100.0	100.0	100.0	100.0	96.2
AM	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Da	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Di	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gh	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	80.0	98.5
Jo	100.0	100.0	100.0	100.0	100.0	50.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.2
Ju	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ma	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Me	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	80.0	98.5
Mis	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Moh	100.0	100.0	100.0	75.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.1
Mon	66.6	100.0	100.0	75.0	100.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	94.0

Mu	88.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1
Nah	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nas	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Os	88.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	80.0	97.6
Re	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sa	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	80.0	98.5
Sau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0	0.0	0.0	30.8
Sh	44.4	100.0	100.0	25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.0
Ta	100.0	100.0	60.0	50.0	100.0	100.	100.0	100.0	100.0	100.0	100.0	50.0	20.0	83.1
Mean[b]	89.9	95.2	93.3	86.9	95.2	91.9	95.2	97.6	100.0	100.0	100.0	92.9	87.6	94.3

a. Mean voiceless segmental accuracy percentage or each child, b. Mean segmental accuracy percentage for each voiceless consonant

8.5 Word-final position

The section below has a similar structure to the previous sections on word-initial and word-medial positions.

8.5.1 Most and least accurate segments (word-final position)

Using the same analysis conducted on word-initial and word-medial positions, the mean percentage of segmental production accuracy in word-final position has been calculated for all children with cleft palate (Table 8-19). From this table, a further table was generated to collect information on the number of children who produced accurate segments in the word final position based on four categories. (See Appendix 6 for percentage of segmental production accuracy for all consonants in word-final position).

8.5.2 Most accurate consonantal segments (word-final position)

As described earlier in word-initial and word-medial positions, the most accurate segments are obtained based on the number of children who produced the consonants with a level of accuracy of between 75% and 100% (Table 8-20). From the table, it is revealed that the most accurately produced segments are the glottal fricative, pharyngeals, the liquid and velars. Table 8-21 presents the consonantal segments produced by ten children or more within the range of 75%-100%.

8.5.3 Least accurate consonantal segments (word-final position)

The consonants in the category 0%-24% represent the least accurately produced segments. The single palatal /j/ is the least accurate segment, where 20 of the 21 children did not produce it accurately. Inaccurate production of this consonant is anticipated as palatal, in some Arabic dialects, is usually substituted by a vowel in word-final position (Omar, 1973; Amayreh and Dyson, 2000). Thus, this would be considered as an accurate variant of the target rather than inaccurate realisation.

This is followed by the emphatic /sˤ/ which only three children produced accurately. The consonants, /ʔ, z, ʃ/, are the second least accurately produced segments; 15 children did not produce them accurately. (For the rest of the least accurately produced segments, see Table 8-21).

Table 8-19 Mean percentage of total segmental accuracy for all children with cleft palate in word-final position

Child initial	Mean [a]
AG	68.7
AM	48.6
Da	60.6
Di	80.8
Gh	52.3
Jo	65.1
Ju	79.9
Ma	56.2
Me	40.7
Mis	76.1
Moh	74.5
Mon	51.1
Mu	54.3
Nah	59.6
Nas	20.9
Os	57.5
Re	78.3
Sa	33.1
Sau	23.5
Sh	34.3
Ta	56.4
Mean [b]	**55.8**

a. Mean segmental accuracy percentage for each child
b. Mean segmental accuracy percentage for all children in word-initial position

Table 8-20 Number of children who produced accurate realisations of individual word-final consonant segments based on four categories of percentage segmental accuracy

Consonants / (%) [a]	0 -24%		25-49%		50-74%		75-100%	
	n	%	*n*	%	*N*	%	*n*	%
b	6	28.6	3	14.2	4	19.0	8	38.0
t	9	42.8	0	0.0	1	4.7	10	47.6
d	2	9.5	4	19.0	7	33.3	7	33.3
k	6	28.6	0	0.0	0	0.0	15	71.4
q	8	38.0	0	0.0	0	0.0	13	61.9
tˤ	9	42.8	0	0.0	0	0.0	12	57.1
dˤ	5	23.8	0	0.0	5	23.8	11	52.4
ʔ	15	71.4	0	0.0	0	0.0	6	28.6
f	5	23.8	0	0.0	3	14.2	13	61.9
θ	6	28.6	0	0.0	4	19.0	11	52.4
ð	9	42.8	0	0.0	0	0.0	12	57.1
s	11	52.4	3	14.2	3	14.2	4	19.0
z	15	71.4	0	0.0	0	0.0	6	28.6
ʃ	15	71.4	0	0.0	0	0.0	6	28.6
sˤ	18	85.7	0	0.0	1	4.7	2	9.5
χ	5	23.8	0	0.0	0	0.0	16	76.1
ʁ	13	61.9	0	0.0	0	0.0	8	38.0
ħ	0	0.0	0	0.0	3	14.2	18	85.7
ʕ	1	4.7	0	0.0	1	4.7	19	90.5
h	0	0.0	0	0.0	1	4.7	20	95.2
dʒ	13	61.9	0	0.0	5	23.8	3	14.2
m	10	47.6	0	0.0	0	0.0	11	52.4
n	0	0.0	2	9.5	5	23.8	14	66.6
r	5	23.8	1	4.7	7	33.3	8	38.0
l	0	0.0	1	4.7	3	14.2	17	80.9
j	20	95.2	0	0.0	0	0.0	1	4.7

Table 8-21 Most and least accurate word-final segments produced by 10 or more children

Most accurate segments produced within the range of 75-100% accuracy		Least accurate segments produced within the range of 0-24% accuracy	
Segments	**Number of children (%)**	**Segments**	**Number of children (%)**
h	20 (95%)	**j**	20 (95.2%)
ʕ	19 (90.5%)	**sˤ**	18 (85.7%)
ħ	18 (85.7%)	**ʔ**	15 (71.4%)
l	17 (80.9%)	**z**	15 (71.4%)
χ	16 (76.1%)	**ʃ**	15 (71.4%)
k	15 (71.4%)	**ʁ**	13 (61.9%)
n	14 (66.6%)	**dʒ**	13 (61.9%)
q	13 (61.9%)	**s**	11 (52.4 %)
f	13 (61.9%)	**m**	10 (47.6%)
tˤ	12 (57.1%)		
ð	12 (57.1%)		
dˤ	11 (52.4 %)		
θ	11 (52.4 %)		
m	11 (52.4 %)		
t	11 (47.6%)		

8.5.4 Percentage accuracy: manner of articulation (word-final position)

Table 8-22 represents the percentage accuracy of each manner of articulation in word final position. The highest accurately produced manner of articulation is nasals at 77.6%, followed by fricatives at 74.6%. Liquids are the third most accurately produced manner of articulation, at 61.6% followed by plosives at 58.5%. As with word-initial and word-medial positions, the affricate is the least accurately produced manner of articulation, at 26.2%. In Table 8-23, manners of articulations are ranked from the highest to the lowest.

Similar to word-initial and word-medial positions, differences were also noted in terms of the percentage achieved by each individual child for each manner of articulation. For instance, while three children produced the affricate with 100% accuracy, 11 children could not produce it at all (0%). Similar variability occurs with different children in other manners of articulation. Table 8-25 presents the minimum, maximum and mean percentages for each manner of articulation in word-final position.

8.5.5 Percentage accuracy: place of articulation (word-final position)

Percentage of accuracy of each place of articulation is presented in Table 8-24. The most accurate places of articulation are pharyngeals and glottals which were produced at levels of 94% and 93% accuracy respectively. Velars followed; they were correctly produced 71% of the time, and finally alveolar at 62%. Labial, dental and uvular came on the same level; these were produced correctly 59% of the time. In Table 8-25, place of articulations are ranked, from the highest to the lowest.

Palatal (i.e. /j/), as shown in the table, is the least accurate place of articulation, where only 5% of the segment was produced accurately by all children. This is, again, suggested to occur due to the tendency to substitute the segment /j/ by vowel /i/ in word final-position as an acceptable variant.

Yet again, inter-speaker variation was evident and velar place of articulation can be taken as an example. While six children never realise velars at all (0%), the rest of the children produced velars accurately (100%). Table 8-25 presents the minimum, maximum and mean percentages for each place of articulation in word-final position.

Table 8-22 Percentage of accuracy of each manner of articulation in word-final position for all children with cleft palate

Child \ Manner	Plosives	Fricatives	Affricate	Nasals	Liquids/Glides
AG	88.9	81.6	0.0	100.0	66.7
AM	66.7	60.5	0.0	42.9	60.0
Da	55.6	76.3	0.0	85.7	80.0
Di	94.4	94.7	0.0	100.0	93.3
Gh	38.9	71.1	50.0	85.7	80.0
Jo	55.6	84.2	50.0	57.1	93.3
Ju	94.4	92.1	50.0	85.7	53.3
Ma	61.1	73.7	0.0	85.7	66.7
Me	55.6	65.8	50.0	42.9	80.0
Mis	77.8	89.5	100.0	85.7	60.0
Moh	77.8	76.3	100.0	100.0	93.3
Mon	66.7	68.4	0.0	100.0	66.7
Mu	77.8	76.3	0.0	57.1	40.0
Nah	94.4	68.4	100.0	85.7	93.3
Nas	0.0	63.2	0.0	42.9	13.3
Os	44.4	76.3	0.0	100.0	66.7
Re	50.0	86.8	50.0	100.0	86.7
Sa	16.7	65.8	0.0	57.1	33.3
Sau	16.7	60.5	0.0	85.7	13.3
Sh	33.3	52.6	0.0	28.6	26.7
Ta	61.1	81.6	0.0	100.0	26.7
Mean [a]	**58.5**	**74.6**	**26.2**	**77.6**	**61.6**

a. Mean segmental accuracy percentage for all children (*n*=21) for each manner of articulation

Table 8-23 Minimum, Maximum and Mean percentages of accurate word-final segments in each manner of articulation

Variables	Mean	Minimum	Maximum
1. Nasals	77.55	29	100
2. Fricatives	74.56	53	95
3. Liquids/Glides	61.59	13	93
4. Plosives	58.47	0	94
5. Affricate	26.19	0	100

*Manners of articulations are ranked according to the mean (from the highest to the lowest)

Table 8-24 Percentage of word-final segmental accuracy for all children with cleft palate based on place of articulation

Place[a] / Child	Labial	Dental	Alveolar	Post-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal	Emphatic[19]
AG	100	100	77	0	0	0	67	100	100	40
AM	50	33	53	0	0	100	33	100	89	20
Da	50	67	70	33	0	100	100	80	95	40
Di	100	100	100	0	0	100	67	100	95	100
Gh	10	100	67	33	0	100	67	100	100	20
Jo	50	100	73	67	0	100	67	100	95	60
Ju	90	100	67	67	0	100	100	100	100	100
Ma	90	67	53	0	0	100	67	80	95	60
Me	60	67	53	33	100	0	0	100	95	40
Mis	80	100	77	100	0	100	33	100	95	60
Moh	80	33	80	100	0	100	100	100	95	60
Mon	80	0	63	0	0	100	33	100	100	40
Mu	90	100	47	0	0	0	100	60	95	60
Nah	90	33	83	67	0	100	33	100	95	60
Nas	10	0	17	0	0	0	33	100	89	0
Os	40	33	83	0	0	100	33	80	89	20
Re	30	100	87	67	0	100	100	100	89	60
Sa	10	33	33	0	0	100	67	80	95	0
Sau	30	0	23	0	0	0	0	100	95	20
Sh	10	33	27	0	0	100	67	100	68	20
Ta	80	33	67	0	0	0	67	100	89	0
Mean[b]	**59**	**59**	**62**	**27**	**5**	**71**	**59**	**94**	**93**	**42**

a. Place of articulation
b. Mean segmental accuracy percentage for all children (*n*=21) for each place of articulation

[19] Emphatics (/$s^ʕ$, $d^ʕ$, $t^ʕ$, $ð^ʕ$/) are included in the table as they share the same secondary articulatory feature but have different places of articulations

Table 8-25 Minimum, Maximum and Mean percentages for accurate word-final segments for each place of articulation

	Variables	Mean	Minimum	Maximum
1.	**Pharyngeal**	94.29	60	100
2.	**Glottal**	93.24	68	100
3.	**Velar**	71.43	0	100
4.	**Alveolar**	61.90	17	100
5.	**Uvular**	58.76	0	100
6.	**Dental**	58.67	0	100
7.	**Labial**	58.57	10	100
8.	**Emphatics**[20]	41.90	0	100
9.	**Post-Alveolar**	27.00	0	100
10.	**Palatal**	0.95	0	20

*Places of articulations are ranked according to the mean (from the highest to the lowest)

[20] Emphatics (/sˤ , dˤ, tˤ , ðˤ/) are included in the table as they share the same secondary articulatory feature but have different places of articulations

8.5.6 Percentage of voiced versus voiceless segmental production accuracy for word-final consonants

8.5.6.1 Voiced segmental accuracy (word-final position)

The average percentage of all voiced segmental accuracy produced by all children was 68.02% (Table 8-26). For segmental accuracy, findings indicate that /j/ is the least accurately produced segment (4.76%) and, as mentioned above, the low percentage of palatal /j/ in word-final position is related to the tendency of Arabic speakers to substitute it with a short vowel which is considered as a normal variant. This is followed by /m/ and /z/ (52.38% and 57.14% respectively). The uvular fricative /ʁ/ is also difficult; this was produced at a 66.67% level of accuracy.

8.5.6.2 Voiceless segmental accuracy (word-final position)

The mean percentage of overall voiceless segmental accuracy in the word-final position is 87.7% (please refer to Table 8-27). The fricative /ʃ/ and pharyngeal /ħ/ were produced accurately 100%. These are followed by dental /θ/, velar /k/ and uvular /χ/ with a percentage of 90% and more level of accuracy. In contrast, the segments least accurately produced are /f/, /tˤ/, and /q/ which were produced at a level of only 76.2 % by all children, followed by the alveolar /t/ at a level of 83.3% and finally /s/ and /sˤ/, both at 85.7%.

Table 8-26 Percentage of voiced word-final segmental accuracy for all children with cleft palate

Voiced / Child Init.	b(7)	m(1)	ð(1)	d(3)	n(6)	r(10)	z(1)	dʒ(2)	j(1)	l(4)	ʁ(1)	ʕ(2)	dˤ(2)	ðˤ	Mean [a]
AG	100.0	100.0	100.0	100.0	100.0	60.0	100.0	0.0	0.0	100.0	0.0	100.0	100.0		73.85
AM	57.1	100.0	0.0	100.0	33.3	70.0	0.0	0.0	0.0	75.0	100.0	100.0	0.0		48.88
Da	57.1	0.0	0.0	33.3	100.0	80.0	0.0	100.0	0.0	100.0	100.0	100.0	100.0		59.26
Di	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0	100.0		84.62
Gh	14.2	0.0	100.0	66.6	100.0	80.0	100.0	100.0	0.0	100.0	0.0	100.0	100.0		66.22
Jo	42.8	0.0	100.0	66.6	66.6	100.0	100.0	100.0	0.0	50.0	100.0	100.0	100.0		71.23
Ju	100.0	0.0	100.0	66.6	100.0	90.0	0.0	50.0	0.0	100.0	100.0	100.0	100.0		69.74
Ma	85.7	100.0	100.0	66.6	100.0	70.0	0.0	0.0	0.0	100.0	100.0	50.0	100.0		67.10
Me	85.7	0.0	0.0	66.6	83.3	80.0	0.0	50.0	100.0	100.0	0.0	100.0	50.0		55.05

Mis	85.7	100.0	100.0	100.0	100.0	60.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0		88.13
Moh	71.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0		90.11
Mon	85.7	100.0	0.0	33.3	100.0	60.0	100.0	50.0	0.0	100.0	0.0	100.0	50.0		59.92
Mu	100.0	0.0	100.0	100.0	66.6	100.0	0.0	100.0	0.0	100.0	100.0	0.0	100.0		66.66
Nah	100.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0		84.62
Nas	0.0	0.0	0.0	0.0	83.3	40.0	0.0	0.0	0.0	100.0	0.0	100.0	0.0		24.87
Os	28.5	100.0	100.0	100.0	100.0	90.0	100.0	100.0	0.0	75.0	100.0	100.0	100.0		84.12
Re	0.0	100.0	100.0	66.6	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0		82.05
Sa	0.0	0.0	0.0	33.3	100.0	30.0	0.0	100.0	0.0	75.0	0.0	100.0	50.0		37.56
Sau	28.5	100.0	100.0	33.3	100.0	90.0	100.0	100.0	0.0	100.0	100.0	100.0	50.0		77.06
Sh	28.5	0.0	100.0	100.0	50.0	30.0	0.0	0.0	0.0	25.0	100.0	100.0	100.0		48.73
Ta	71.4	100.0	100.0	100.0	100.0	80.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0		88.57
Mean[b]	59.16	52.38	71.43	72.99	89.67	76.67	57.14	69.05	4.76	90.48	66.67	92.86	80.95		68.02

a.Mean voiced segmental accuracy percentage or each child, b. Mean segmental accuracy percentage for each voiced consonant

Table 8-27 Percentage of voiceless word-final segmental accuracy for all children with cleft palate

Child Init. \ Voiceless	f(2)	θ(2)	t(2)	s(4)	ʃ(1)	k(1)	q(1)	χ(1)	ħ(3)	sˤ(2)	tˤ(1)	Mean[a]
AG	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AM	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Da	100.0	100.0	0.0	50.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	86.4
Di	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gh	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.9
Jo	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ju	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ma	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Me	0.0	100.0	0.0	100.0	100.0	0.0	0.0	0.0	100.0	100.0	100.0	54.5
Mis	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	90.9

Moh	100.0	100.0	100.0	50.0	100.0	100.0	100.0	100.0	100.0	50.0	100.0	90.9
Mon	50.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	77.3
Mu	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nah	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nas	100.0	100.0	50.0	75.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	75.0
Os	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	90.9
Re	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sa	50.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.5
Sau	0.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0	100.0	0.0	0.0	45.5
Sh	0.0	100.0	0.0	25.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0	56.8
Ta	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	50.0	0.0	86.4
Mean[b]	76.2	95.2	83.3	85.7	100.0	90.5	76.2	95.2	100.0	85.7	76.2	87.7

a.Mean voiceless segmental accuracy percentage or each child, b. Mean segmental accuracy percentage for each voiceless consonant

8.6 Association between accurately produced segments in all word positions and (age at assessment and age at repair in all children with cleft palate

A Pearson correlation test was used to investigate whether there is a relationship between the total accurate number of articulations in all word positions and age at assessment and age at repair (in months).

The results indicated that there was a negative relationship between the total number of accurate segments in all word positions and age at assessment (r=-0.035) as well as age at repair (r=-0.060). However, the association was not statistically significant for either age at assessment (p=0.880) or age at repair (p=0.795).

8.7 The effect of cleft type on the accurate production of segments in all word positions

Descriptive analysis was performed to recognise the effect of each type of cleft palate on the consonant production. It was not possible to test the effect statistically as the number of children in each type of cleft is not equivalent. The effect of cleft type on the accurate production of segments was performed by identifying the total segmental accuracy produced by children with each cleft type in all word positions (See Table 8-28). As shown in Table 8-28, the results indicate that SPO cleft-type has the highest total number of accurate productions in all word positions; followed by UCP. On the other hand, BCLP and BCP are the groups that scored lowest.
Thus, it was found that bilateral cleft-types have the greatest effect on the accuracy of consonant production.

Table 8-28 Participants (age at assessment, age at repair and total accurate segments)

Child Initial	Age at assessment (in months)	Age at repair (in months)	Total accurate segments
DA	48	15	223
MA	48	8	214
Nah	48	22	233
Mu	50	10	190
AM	57	12	206
Os	57	22	210
Mis	60	19	243
Sh	61	24	149
Di	64	23	240
Mon	64	15	191
Ta	64	9	168
Sa	67	12	177
Ju	68	15	240
Sau	70	16	98
Jo	79	14	233
Re	79	9	247
Gh	80	10	225
Nas	81	16	108
AG	84	12	233
Moh	84	15	244
Me	87	21	193

Table 8-29 Average of total accurate segments for each cleft group in all word positions

Type of Cleft	*n*	Mean	Minimum	Maximum
BCLP	4	174.0	98.0	214.0
BCP	4	175.7	108.0	240.0
UCLP	5	217.4	177.0	244.0
UCP	5	221.2	168.0	247.0
SPO	3	224.3	210.0	240.0

* BCLP =bilateral cleft lip and palate; BCP =bilateral cleft palate; UCLP=unilateral cleft lip and palate; UCP=unilateral cleft palate; SPO=cleft of the soft palate only

8.8 Summary of results and hypotheses

In this section, the hypotheses listed at the beginning of this chapter are considered in light of the results:

1. Consonants in word-medial positions are more accurately produced than consonants in word-initial and word-final positions.

Hypothesis one is partially upheld, since segments in word-medial position, as well as word-initial position, are significantly more accurately produced (75.2% and 71% respectively) than segments in word-final position (55.8%). (See Tables 8-3, 8-10, 8-19).

2. In general, fricatives and plosives produced by the body of the tongue (i.e. /χ, ʁ, ħ, ʕ/) are more accurate than those produced by the blade of the tongue (i.e. / t, d, tˤ, dˤ, s, z, sˤ, ʃ, dʒ/).

Hypothesis two is upheld. In general, the results revealed that consonants produced by the body of the tongue are more accurate than consonants produced by the blade of the tongue in all word positions. Thus, results of each word position revealed the following:

In word-initial position, fricatives and plosives produced by the body of the tongue are indeed more accurate than those produced by the blade of the tongue (See Table 8-3).

In word-medial position, results revealed that consonants produced by the body of the tongue are more accurate than consonants produced by the blade of the tongue (See Table 8-14).

In word-final position, results revealed that that velars and uvulars (except /ʁ/) are more accurate than alveolar and postalveolar consonants (See Table 8-21).

3. Fricatives are the least accurately produced manner of articulation in cleft palate speech.

Hypothesis three is not upheld. Fricatives are not the least accurately produced manner of articulation in all word positions (initial, medial and final). Although word initial and medial positions, fricatives are the second least accurate manner of articulation (after affricate), in word-final position, fricatives come as the second-most accurately produced manner of articulation (See Tables 8-5, 8-14 and 8-25).

4. Alveolars (i.e. /t, d, tˤ, dˤ, s, z, sˤ, n, l, r/) and postalveolars (i.e. /ʃ, dʒ/) are the least accurately produced places of articulation in cleft palate speech (i.e. compared with bilabial, labiodental, palatal, velar, uvular, pharyngeal and glottal).

Hypothesis four is partially upheld. Postalveolars are, indeed, the least accurately produced place of articulation in word initial and medial positions. For word final position, palatal (i.e./j/) was the least accurately produced place of articulation and palato-alveolar was the second least accurately produced place of articulation. However, as mentioned above, the reason behind that is the tendency to replace /j/ with [i] word finally (Omar, 1973; Amayreh and Dyson, 2000). On the other hand, results showed that emphatics are considered to be the third most difficult place of articulation in word-final position and the second most difficult place articulation in word initial and medial positions (See Tables 8-7, 8-16 and 8-25).

5. Pharyngeals and glottals are the most accurately produced place of articulation in cleft palate speech.

Hypothesis five is upheld. Pharyngeals and glottals are the most accurately produced place of articulation in all word positions. (See Tables 8-7, 8-16 and 8-25).

6. Voiced stops are more susceptible to misarticulations than voiceless plosives.

Hypothesis six is not upheld for all word positions. That is, results showed that the voiced segmental accuracy in word initial and medial positions is better than for voiceless consonants. However, in final position, the overall accuracy of voiceless consonants is better than the voiced ones. For the percentage of voiced segmental accuracy, see Tables 8-8, 8-17, 8-26), for voiceless segmental accuracy, see Tables 8-9, 8-18, 8-27).

7. Accuracy of segmental production is inversely correlated with age at assessment and age at repair.

Hypothesis seven is not upheld. Result shows that there is no relationship between the total accurate number of articulations in all word positions and the two variables age at assessment and age at repair (See section 8.5.5). The non-significant correlation between total number of accurate segments in all word positions and age at assessment and age at repair might be related to the relatively small sample size, which thus affects the statistical power. This possibility will be discussed further in Chapter 10.

8. Bilateral Cleft Lip and Palate (BCLP) has the most severe effect on the accuracy of production of consonantal segments.

Hypothesis eight is upheld. The BCLP group has the lowest overall rate of segmental accuracy in all word positions, though it was closely followed by the BCP group. However it was not possible to demonstrate that the difference between groups is statistically significant, due to the small number of children in each group (See section 8.5.6).

The implications of these findings are discussed in Chapter 10.

Chapter 9 **Variability and Individual Differences**

Considerable inter- and intra- speaker phonological variability and individual differences has been noted in the speech of children with cleft palate in this study. Intra-speaker variability was sometimes observed in terms of realisations which differed based on word positions and/or elicitation mode (i.e. spontaneous versus repetition). Inter-speaker variability was also noted in the current study where, for example, the speech of one speaker is mainly affected by backing process, whereas other speaker's speech is mainly affected by, for example, nasal turbulence. Such variations have been reported in the literature (e.g. Estrem and Broen, 1989; Chapman, 1993) and as has been suggested by different studies, the variations could be related to different factors, including: the effect of a history of cleft palate (Harding and Grunwell, 1996), part of children's normal phonological development (McLeod and Hwett, 2008) or as a consequence of phonological impairment (Dodd, 1995).

The current chapter has been devoted to describe the diverse and creative responses of children in this data. It illustrates inter- and intra-speaker variability from the speech of four participants selected from the group of children with cleft palate. The four children will be compared in this chapter where they have a strikingly different speech output patterns. These different patterns will enable exploration of the kinds of differences across children which have been identified among the data. For each child, the segmental phonological analysis provided by the Saudi Arabian GOS.SP.ASS consonant chart is compared to the type of phonological analysis provided by the PACS. As already reported, GOS.SP.ASS was chosen because it is an internationally accepted assessment tool (Sell *et al*., 1999), however, the problem with the GOS.SP.ASS is that it only captures an individual token for the target sound in each word position. In addition, GOS.SP.ASS does not capture intra-speaker variability at word positions.

On the other hand, PACS is an effective tool in capturing more tokens for the targets in each word positions.

9.1 Nasreen: Phonological consequences of glottal articulation

Nasreen has been chosen as one of the individual case studies as her speech, in comparison with other children, is characterised by a particularly pervasive pattern of glottal articulation. She is also a case of a child whose speech patterns show low phonetic and phonological variability. Her data will be presented in two types of analysis: the consonant production section of the Saudi Arabian GOS.SP.ASS, then the System of Contrastive Phones analyses from PACS (Grunwell, 1985).

Glottal articulation has been described along with other patterns as a 'compensatory articulation' which occurs as a consequence of velopharyngeal incompetence (Sell *et al.*, 1994). Trost-Cardamone (1997) reported that glottal stops [ʔ] and/or the voiceless glottal fricative [h] are common replacements for fricatives and affricates as well as stops- in other words, for all of the pressure consonants. The glottal stop, in particular, is considered to be the most common compensatory articulation produced by children with cleft palate (Peterson-Falzone, 1989; Trost-Cardamone, 1990). Sell and her colleagues (1994) noticed that the most frequently substituted consonants occur for voiceless plosives. Shahin's (2006) findings on Arabic revealed that glottal replacement was evident only for stops, with no glottal substitutions reported for fricatives and affricates.

Findings relating to glottal articulations were reported for the whole group in section 7.5.1.6. A glottal pattern was identified in a number of children, with a particularly pervasive use of glottals in a few individual cases, including Nasreen, the subject of this case study.

Prior to the presentation of Nasreen's case study, the following predictions could be made based on the studies mentioned above:

- Glottal stop realisations of target pressure consonants would be predicted to occur more frequently than glottal fricative realisations.
- Glottal realisations will only affect target stops and not target fricatives or affricates, or they will affect target stops more than target fricatives and affricates.

9.1.1 Single word productions

Table 9-1Nasreen:
GOS.SP.ASS consonant chart based on single word data

Single words	Labial			Dental		Alveolar							Post-alveolar		Velar
Target	**m**	**b**	**f**	**ð**	**θ**	**n**	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**k**
Word Initial	m	m	ʔ	ʔ	ʔ	n	n	ʔ	ʔ	ʔ	ʔ	ɾ	ʔ	ʔ	ʔ
Word Medial	m	m	ʔ	ʔ	ʔ	n	l	ʔ	ʔ	t̚ ʰ	ʔ	w	ʔ	ʔ	ʔ
Word Final	m̥	m̥	h	(ð)	ʔ	n	l̚	(t)	(d)	h	ʔ	ɾ	h	h, ʔ	ʔ

Single words	Emphatics				Uvular			Pharyngeal		Glottal	
Target	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**
Word Initial	ʔ	ʔ	ʔ	ʔ	ʕ	x	ʔ	ħ	ʕ	h	ʔ
Word Medial	ʔ͡q	ʔ	ʔ	ʔ	ʕ	ħ	ʔ	ħ	ʕ	h	ʔ
Word Final	h	ʔ	—	…	x	x	—	ħ	h	h	h

9.1.1.1 Cleft palate realisations

Table 9-1 presents consonant data from Nasreen's single word productions. Each target consonant is sampled once in each position. The most pervasive feature in Nasreen's speech is glottal stop articulation which affects plosives, the affricate and fricatives except for uvular and pharyngeal (i.e.

back) fricatives. This pattern is most evident in word- initial and word-medial positions.

In word-final position, she tends to use a glottal fricative more than a glottal stop. This may be a consequence of incomplete closure of strictures at the final position of the word. As noticed in a number of studies, typically-developing children tend to replace stops with fricatives and affricates word finally (until the age of two-year-old) (Olmsted, 1971, Oller 1973; Oller *et al.*, 1976). It could be possible to note typically developing early process appearing at later ages for children with cleft palate/impaired speech (Harding and Howard, 2011). Thus, this could be an explanation for Nasreen's preference to use glottal fricative instead of stops at word-final positions.

Observation of the video recording indicated that Nasreen achieved the appropriate tongue position for the production of the targets, /t/, /d/ and /ð/ in word-final position, however, she failed to produce an accompanying airstream and thus the articulation was silent (i.e. (t), (d) and (ð)). A possible explanation is that she is unable to sustain the airstream until the release of the stop in word-final position related to the effect of VPI (the ExtIPA symbol (-) was used to indicate deleted and/or unproduced consonants).

Along with the occurrence of the above mentioned behaviours Nasreen used a weak alveolar stop [t͈] just once as a replacement for alveolar fricative /s/ in word-medial position /ʔæs.nan/→[ʔæt̚ʰ.nan]'teeth'. Given this evidence of the ability to produce an alveolar plosive, it is suggested that Nasreen's use of glottal stops might actually obscure simultaneous alveolar articulations and that she might, at least part of the time, be producing alveolar-glottal double articulations that are not perceptible as such to the listener. Even though there was only an occurrence of this realisation (which Grunwell, 1985, suggests should usually be ignored in clinical assessment), it does suggest an interesting possibility which could be tested using instrumental analysis such as EPG. However, as reported in Chapter 4, it is important to develop randomised controlled trials before the technique is adopted in assessment of individuals with cleft palate (Lee *et al*., 2009).

She also used double articulation [ʔ͡q] in word-medial position as a replacement for the emphatic /sˤ/ (e.g. /ʕasˤiːr/ →[ʕaʔ͡qiːɾ] 'juice'). Rather than the glottal pattern seen for other oral consonants, she realised the target bilabial oral consonant /b/ as a homorganic nasal in all word positions.

9.1.1.2 Developmental realisations

The data also show the occurrence of some errors related to typical developmental phonological processes, including developmental backing of voiced uvular fricatives to pharyngeal place of articulation /ʁ/→ [ʕ] (more description for the developmental backing is provided in section 7.5.1.6). In one instance she also used the voiceless uvular instead of the voiced production (i.e. /ʁ/ →[ʕ]). Furthermore, she tends to delete consonants in the final word position (i.e. which, as Ingram (1976) reported, could be considered as a developmental speech disorder).

9.1.2 Sentence repetition

Table 9-2Nasreen: GOS.SP.ASS consonant chart based on sentence data

Sentences	**Labial**			**Dental**		**Alveolar**							**Post-alveolar**		**Velar**
Target	**m**	**b**	**f**	**ð**	**θ**	**n**	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**k**
Word Initial	m	m	ʔ	ʔ	ʔ	n̪̊	l	ʔ	ʔ	ʔ	ʔ	ɾ	ʔ	ʔ	ʔ
Word Medial	m	m	ʔ	ʔ	ʔ	n̪̊	(-)	ʔ	ʔ	ʔ	ʔ	w	ʔ	ʔ	ʔ
Word Final	m	m	ʔ	ʔ	ʔ	n̪̊	l̞	ʔ	(-)	(-)	ʔ	(-)	h	(-)	h

Sentences	**Emphatics**				**Uvular**			**Pharyngeal**		**Glottal**	
Target	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**
Word Initial	ʔ	ʔ	ʔ	ʔ	ʔ	ħ	ʔ	ħ	ʕ	h	…
Word Medial	ʔ	q	q	ʔ	ʔ	ħ	ʔ	ħ	ʕ	h	…
Word Final	—	…	…	h	–	ħ	ʔ	ħ	ʕ	h	…

9.1.2.1 Cleft palate realisations

The speech data from Nasreen's repetition of the GOS.SP.ASS sentences do not differ greatly from those in single word productions. This applies to all word contexts and there is no difference whether the word final targets are also utterance final or within a sentence.

Thus, as with single word productions, there are three pervasive patterns - glottal realisations, nasal realisations and final consonant deletion and/or final silent articulation - of which the glottal realisations are the most frequently occurring pattern.

Generally, when describing her speech in relation to cleft type characteristics, her profile shows very few oral consonants used for target oral pressure consonants. As already evident, she is using glottals for most of the pressure consonants which is greatly affecting her intelligibility by significantly reducing the number of phonological contrasts she is able to make. Furthermore, her speech is affected by passive cleft type characteristics including weak consonants and nasal realisation of plosives. All of these patterns are likely to have emerged as a response to having velopharyngeal inadequacy (Harding and Grunwell, 1998). As might be predicted from the literature (Sell *et al.*, 1999) her realisations of nasal, approximant, pharyngeal and glottal consonant targets do not appear to have been affected by the presence of cleft palate. Therefore, with regard to the predictions stated above, the data show the following:

- Glottal stops are more frequently used by Nasreen than glottal fricatives in both single word production and sentence repetition.
- Glottal articulations affect almost all of her pressure consonant targets (including the emphatics) but not nasals and approximants, which were either developmentally substituted by other sounds or deleted word finally.
- Glottal articulation also does not affect pharyngeals or the voiceless uvular fricative. Therefore, the present results support predictions about glottal usage based on other languages, but not, interestingly, Shahin's (2006) findings.

9.1.2.2 Developmental realisations

In addition to cleft palate errors, Nasreen also had other phonological errors not related to the presence of cleft palate. As mentioned earlier, Nasreen, along with many children in the current study (see section 7.6.6), has a language-specific developmental process, namely non-cleft pharyngeal backing of voiceless uvular fricatives to a pharyngeal place of articulation. In her single words, this affected both voiced and voiceless targets. In the sentence production data, it only applied to the voiceless target, /χ/→[ħ]. This was the only developmental process noted in Nasreen's data, which were generally most significantly affected by the pattern of glottal realisations.

9.1.3 PACS analysis

A selected section of the Phonological Assessment of Child Speech (PACS: Grunwell, 1985) provided further useful information about Nasreen's speech output patterns. The section includes *System of Contrastive Phones*[21]which has been used to evaluate and compare contrastive phones with the target phonemic system.Also it is thought to be useful in terms of including different realisations which occur for a given target segment in different tokens.

9.1.3.1 System of Contrastive Phones and Contrastive Systems

The System of Contrastive Phones framework involves all of the child's realisations for all of the target segments in all possible targets in single words and sentences. This differs from the GOS.SP.ASS consonant analysis above, which only contains a single token of each target segment produced by the child in a single word. Analysis of Nasreen's System of Contrastive Phones (Figure 9.1) based on her realisations of the adult targets across all of her speech production reveals a profile which could be described as remarkably consistent and invariable. The reason is that her sound system is constrained, especially for target anterior sounds [22] which tend to be glottal. For posterior sounds[23], specifically uvular and pharyngeal sounds, Nasreen tends either to use a non-cleft pharyngeal backing (see section 7.8.6), as in /χ/ →[ħ], /ʁ/ →[ʕ], to use socio-phonetically acceptable variants/χ/ →[x], or simply to produce the sounds correctly /ʕ/. Furthermore, the alveolar trill is replaced by approximants [w,ʋ] which, in case of [w], could be considered as developmental error (Ayyad, 2011). As reported by Brøndsted *et al*. (1994), glottal articulation does not directly occur as a consequence of structural abnormality, but rather occurs as a compensatory strategy "adopted by the speech production system to overcome or minimize the effects of this deficit" (Brøndsted, *et al*., 1994:113). Such a strategy can persist even after surgical repair of cleft palate as consequence of habituation (e.g., Chapman, 1993; Bzoch 1997). This may be relevant in

[21]Another way of information for the four case studies is also presented in the PACS feature contrastive chart in Appendix(7)

[22]Anterior sounds include labials ,dentals ,alveolars
[23] Posterior sounds include palato-alveolars, palatals, velars, uvulars, pharyngeals.

Nasreen’s case as her ‘speech progress reports’ reveal that she did not frequently attend the speech therapy sessions. In the absence of therapy she would be more likely to thus maintain such a strategy in her speech.

With regard to different word positions, glottal stop realisations of pressure consonants are widely used in word-initial and word-medial positions. However, word-final position is interesting in particular as in addition to using glottal stop articulation as a replacement for most of the oral targets; she used glottal fricative realisations for some segments (context-sensitive variants of glottal realisations, that is glottal stop in initial and medial positions and glottal fricative in final position). Additional features also emerged in word-final position including deletion for some of the target segments (i.e. /t, d, tˁ, q/) which could be considered as a developmental process, i.e. Final Consonant Deletion (Ingram, 1976) .

Despite the pervasive glottal patterns in Nasreen’s speech, she used a few productions of weak oral consonants for the targets /s/ in word initial position and /ð/ in word-final position. Thus, for the former she used an aspirated weak alveolar production [t͉ʰ] and for the latter a weakly articulated version of the acceptable variant [d͉]. As mentioned earlier, her use of glottal stops could in fact obscure simultaneous alveolar articulations and she might, at least part of the time, be producing alveolar-glottal double articulations that are not perceptible as such to the listener. It could also be suggested that her use of plosives as replacements for target fricatives might be a manifestation of the typical developmental process, of stopping.

In general, theanalysis of Nasreen’s data revealed a sound system that is mainly characterised by glottal articulation which has been considered within the category of compensatory articulation (Sell *et al.,* 2009). For almost all of the target segments, glottal stop was used as a replacement in word-initial position and word-medial position. However, for word-final position the child tended to use glottal fricative instead of glottal stop.

9.1.4 Conclusion of Nasreen's case study

Nasreen's speech could be generally described as: consistent, fairly inaccurate, fairly consistent productions in single words than sentences. A summary of Nasreen's case is given based on the following questions:

The pattern of Nasreen's segmental productions (i.e. both single words and sentences) shows fairly consistent realisations in word- initial and word-medial positions. In word-final position the child usually tends to use either glottal fricative or delete the consonant.

Both single words and sentences showed inaccurate production for almost all of the target segments except for nasals, pharyngeal and glottals.

m ʔ n ʕ x h j ʊ ʔw w ħ	**m** m		**n** n		Word-initial position							
		b m	**t** ʔ	**d** ʔ			**k** ʔ		**q** ʔ	**tˤ** ʔ	**dˤ** ʔ	**ʔ** ʔ
	f ʔ		**θ** ʔ	**ð** ʔ	**ʃ** ʔ	**dʒ** ʔ	**χ** x	**ʁ** ʕ		**ðˤ** ʔ	**ʕ** ʕ	
			s ʔ	**z** ʔ						**ħ** ħ	**sˤ** ʔ	
	w w		**r** ʊ, ʔw l n		**j** j		**h** h					

m ʔ n ʕ x h j ʊ w l ħ t̚ʰ	**m** m		**n** n		Word-medial position							
		b m	**t** ʔ	**d** ʔ			**k** ʔ		**q** ʔ	**tˤ** ʔ	**dˤ** ʔ	**ʔ** ʔ
	f ʔ		**θ** ʔ	**ð** ʔ	**ʃ** ʔ	**ʒ** ʔ	**χ** ħ	**ʁ** ʕ		**ðˤ** ʔ	**ʕ** ʕ	
			s t̚ʰ	**z** ʔ						**ħ** ħ	**sˤ** ʔ	
	w w		**r** w **l** l		**j** j		**h** h					

m ʔ n ʕ x h i ʊ l ħ	**m** m̥		**n** n		Word-final position							
		b m	**t** (t)	**d** (d)			**k** ʔ		**q** (q)	**tˤ** (tˤ)	**dˤ** ʔ	**ʔ** --
	f h		**θ** ʔ	**ð** d̚	**ʃ** h	**dʒ** ʔ	**χ** x	**ʁ** x		**ðˤ** --	**ʕ** ʕ	
			s h	**z** ʔ						**ħ** ħ	**sˤ** ʔ	
	w --		**r** ʊ **l** l		**j** i		**h** h					

Figure 9-1 Nasreen's Systems of Contrastive Phones and Contrastive Systems

9.2 Saud: Phonological consequences of nasal articulation

Nasal realisation of oral pressure consonants, e.g. [m] for /b/ or /f/, is considered to be a passive characteristic of cleft palate speech (Sell *et al*., 1999). The pattern occurs when the intraoral pressure is reduced due to the presence of palatal fistulae or VPI and is also sometimes related to the presence of hearing loss (Donahue, 1993).

Saud was chosen because he combined a range of interesting patterns. He demonstrates a pattern of nasal realisations such as is common in cleft speech cross-linguistically, but his realisations of target segments specific to Arabic are also worthy of comment. The patterns of variability in his speech differ noticeably from those of Nasreen. As well as demonstrating a fairly pervasive pattern of nasal realisations he also deals with trills unusually and has some typical developmental stopping, using [d, $d^{ʕ}$] as a substitution for /$s^{ʕ}$, z/. As with Nasreen, Saud's case study is based on data from elicited single words and sentence repetition, both taken from the Saudi Arabian GOS.SP.ASS. Selected portion of PACS will again be used to explore segmental variability more thoroughly.

Table 9-3Saud:

GOS.SP.ASS consonant chart based on single word data

Single words	Labial			Dental		Alveolar							Post-alveolar		Velar
Target	**m**	**b**	**f**	**ð**	**θ**	**n**	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**k**
Word Initial	m	m	n̪̰	ʔ	θ	n	n̪̰	w̪̰	n	θ	ʔ	w	n	n̪̰	n
Word Medial	m	m	n̪̰	n̪̰	n̪̰	nʰ	_	n	d	n	d̚ˤ	(r)	n	n̪̰	n̪̰
Word Final	mʰ	b̚	(f)	n̪̰	n̪̰	n	l	(t) ʰ	(d)	(s)ʰ	nʔʰ	(r̰)	l	n̪̰	l ʰ

Single words	Emphatics				Uvular			Pharyngeal		Glottal	
Target	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**
Word Initial	n̪̰	n̪̰	ð	ðˤ	ʕ	ħ	n̪̰	ħ	ʕ	h	ʔ
Word Medial	dⁿ	dˤ	n̪̰	d̚ˤ	ʕ	ħ	n̪̰	h	ʕ	h	ʔ
Word Final	d̚ˤ	d̚ˤ	n̪̰	..	ʕ	ħ	n 1st ʔ 2nd	ħ	ʕ	h	_

9.2.1 Single word productions

9.2.1.1 Cleft palate realisations

Table 9-3 presents speech data from Saud's single word production which shows a pattern of nasal realisation affecting mainly pressure consonants. However, this pattern is not consistent for all consonants in all word positions as, for example, Saud used a glottal articulation to produce /ð/ in initial position as compared with nasal realisations in word-medial and word-final positions. The voiced alveolar fricative target/ z/ was also realised as glottal stop in word-initial position and produced as a weak emphatic [d̚ˤ] in word-medial position. Furthermore, the nasal realisation of /z/ that occurs in word-final position in the target word /mɔz/ 'banana', was followed directly by an aspirated glottal stop: thus [mɔn.ʔʰ]. For the latter it is suggested that Saud was trying to mimic the realisation of /z/ by maintaining the place of articulation and voicing but due to the loss of intra-oral pressure he produced nasal consonant as a replacement for /z/. For the following realisation of [ʔʰ] the child might be trying to stop the nasal realisation by producing a glottal stop followed by friction.

For the voiceless member /s/ of this pair of target, the child used a developmental phonological process for the target i.e. /s/→[θ], in word-initial position, nasal realisation i.e. /s/→[n] occurred in word-medial position and the target was deleted in word-final position. Thus, developmental phonological processes occur in word-initial and word-final positions.

A further behaviour found frequently in Saud's speech production is his use of a linguolabial place of articulation while producing as nasal a number of consonants including /f, ð, θ, l, t, d, dʒ, sˤ, dˤ, tˤ, k, q/. For example, he replaced the target /d/ with a linguolabial nasal articulation (e.g. /mʊχad.dah/ →[mʊħan̼.n̼ah]). A possible explanation for the linguolabial behaviour is that the child is experiencing difficulty in placing the tongue in the right position for sounds that require the tip or blade (e.g. for the target dentals and alveolars) of the tongue to produce it. Thus, it would be anticipated that the child would receive benefit from applying EPG in therapy. Hence, with EPG the child can visualise the placement of his tongue during speech and correct the tongue-palate placement error by imitating the prescribed patterns of contact on the EPG display screen (e.g. Wood *et al*., 2008).

9.2.1.2 Developmental realisations

Other than cleft palate errors, developmental phonological processes were also identified in his speech. As reported previously, the child used a developmental phonological process for the target (i.e. /s/→[θ]) in word-initial position. Furthermore, for voiceless uvular fricative /χ/ and voiced uvular /ʁ/, Saud has displayed phonological processes by producing the consonant in a more posterior position as shown in the following example: /mʊχad.dah/ →[mʊħan̤. n̤ah] 'pillow'; /maʁ.salah/ →[nʊʕ. n̤ɪ n̤ah] 'water sink'. As explained earlier, the latter process is called non-cleft pharyngeal backing and it differs from the backing process which occurs as a consequence of cleft palate (i.e. cleft pharyngeal backing).

The differences between non-cleft pharyngeal backing versus cleft pharyngeal backing could be described as follows:

- Non-cleft pharyngeal backing involves posterior placement of uvular fricative targets to pharyngeal place of articulation.

Non-cleft pharyngeal backing																				
Alveolar							Post-alveolar		Emphatics				Velar	Uvular			Pharyngeal		Glottal	
n	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**K**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**

- Cleft pharyngeal backing involves posterior placements of alveolar targets to uvular or pharyngeal place of articulation.

Cleft pharyngeal backing																				
Alveolar							Post-alveolar		Emphatics				Velar	Uvular			Pharyngeal		Glottal	
n	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**k**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**

The phonological process of gliding also occurs in terms of Saud's realisations of the alveolar trill, realised as [w] in word-initial position: this has previously been reported as a process found in normal phonological development in Arabic (Ayyad, 2011). On the other hand, /r/ is deleted in word-medial and word-final positions of the word in Saud's speech production. According to the literature, Arabic /r/ usually starts to develop by the age of 3 but is not completely mastered till around the age of 5:6 (Dyson and Amayreh, 2000:84). In typical phonological development, the sound can be either realised as tap or trill (Nasr, 1966: 5; Shaheen, 1979: 142, Anani, 1985: 132). Moreover, in normal development /r/ can also be deleted (e.g. /faːr/ → [fa] 'Mouse'), assimilated (e.g. /ʔɪr.sʊm/→[ʔɪs.sʊm] 'Paint' or substituted (e.g. /ʔɪr.sʊm/→[ʔɪl.sʊm] 'Paint'). Further description for Saud's trill will be provided in the coming section.

9.2.2 Sentence repetition

Table 9-4 Saud's speech production:
An analysing using GOS.SP.ASS consonant chart sentence repetition data

Sentences	**Labial**			**Dental**		**Alveolar**							**Post-alveolar**		**Velar**
Target	**m**	**b**	**f**	**ð**	**θ**	**n**	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**k**
Word Initial	m	b̚	n	n	n̼	n	n	n	d̚	n	n̼	w	n̼	n	n̼
Word Medial	m	m̥	n	n	n̼	n	n	n	d̚	n	n̼	d̚ˤ	n	n	n̼
Word Final	m̥	m̥	n	n	n̼	n	n	n	d̚	n	n̼	n	n̼ʰ	n̼	n̼

Sentences	**Emphatics**				**Uvular**			**Pharyngeal**		**Glottal**	
Target	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**
Word Initial	n̼	n	n̼	n̼	ʕ	ħ	ʔ	ħ	ʕ	h	…
Word Medial	n̼	d̚	n	n̼	ʕ	ħ	ʔ	h	ʕ	h	…
Word Final	n̼	d̚	( )	…	ʕ	ħ	( )	ħ	ʕ	h	…

9.2.2.1 Cleft palate realisations

For the target segments, the sentence repetition data show some similar patterns as the single word data. For sentence repetition data, however, more consistency was noticed in the use of nasal realisation for oral consonants. A nasal pattern occurred in the realisation of target labials /b, f/, dentals /ð, θ/, alveolars /l, t, s, z/ and post alveolars /ʃ, dʒ/, dental and alveolar emphatics (/sˤ, tˤ, ðˤ/) and the velar /k/. Thus, the child produced nasal realisations for all pressure consonants

Saud showed an ability to produce weak alveolar plosive [d͉], using it for the production /d/ in all word positions and /dˤ/ in word-medial and word-final positions. In fact, /dˤ/, as well as other emphatics, is usually de-emphasised in normal phonological development in Arabic (e.g. Ayyad, 2011).Thus, Saud is substituting /dˤ/ with [d͉] in line with normal phonological development, while the weak production occurs as one possible consequence of velopharyngeal dysfunction (Kummer *et al.*, 1992).

As with Nasreen, Saud’s speech pattern can be described as having occasional alveolar and bilabial plosives, within frequent evidence of passive cleft type characteristics, i.e. weak consonants, nasal realisation of plosives and fricatives as well as absent pressure consonants. These patterns appear to result from a passive strategy being adopted in response to velopharyngeal inadequacy (Harding and Grunwell, 1998).

9.2.2.2 Developmental realisations

Similar to the single word data, the sentence repetition data show some phonological errors that are not related to the presence of cleft palate. Thus, Saud used a developmental backing process which only affected the posterior oral sounds /χ, ʁ/ -e.g. in

/χʊluːd tɪχ.lɪtˤ əl.χɔχ/, all the voiceless uvular fricatives are realised as [ħ]

and in:

/ʁasalt əʃ.ʃʊmaːʁ fɪl maʁ.salah/ all the voiced uvular fricatives are realised as [ʕ]

9.2.2.3 Other idiosyncratic realisations

As described earlier, the alveolar trill was produced differently across different word positions in the single word data and the same occurs in sentence repetition data: in /raman ɑːsˤɪr əl.kuːrah/, /r/ was realised word initially by a glide [w], word medially by a plosive [dˤ] and word finally by a nasal [n].

9.2.3 PACS analysis

As with Nasreen, some sections of the PACS (i.e. System of Contrastive Phones) are included as they are helpful in showing the patterns of variability in Saud's speech production.

9.2.3.1 System of Contrastive Phones and Contrastive Systems

In this section analysis of Saud's speech output using the PACS System of Contrastive Phones is presented. This analysis involves all of the child's different realisations for the all tokens from all single words elicitations conditions. This differs from the GOS.SP.ASS analysis as the latter only contains the target segment produced by the child in a single token for each word context. Thus, this analysis can reveal more details about variability, particularly for different tokens of the same target in the same context.

Generally and as was the case for many children in this study, variability was markedly evident in Saud's data, in which variable realisations occur for the same target segment across different word positions (word-initial, word-medial, word-final). Thus, along with nasal and glottal production of oral consonants, other idiosyncratic replacements were also noticed. This occurred, for example, for the target sound /sˤ/ in which the child realised the target consonant as a nasal in word- initial position but replaced it with a nasalised alveolar plosive [d̃][24] in word- medial position and used a weak emphatic sound [d̹ˤ] as a replacement for the target sound in the word-final position. In fact, for the target /dˤ/ and its equivalent non-emphatic consonant /d/, Saud was producing them either correctly, weakly or nasally. As also noticed, he tends to use them interchangeably as a replacement for some of the other consonants such as /z,dˤ,ðˤ/ in different word positions. Another example of context-sensitive variability is for the voiceless velar stop: Saud realised /k/ as a linguolabial nasal in word-initial and word-medial positions but used an aspirated lateral approximant as a replacement for the segment in the final position of the word. The word /kɛːk/ 'Cake' is an interesting example for demonstrating such variability where two tokens of /k/ occur in the same word and are produced differently by Saud: [n̼ɛːlʰ].

Variability was not only evident for specific target segments across different word-positions, but there was, in addition, variability across different words or word tokens. For example, for the target segment /d/ different realisations

[24]Nasal realisation of voiced plosives[d̃] was not mentioned in the ExtIPA ,however it was noted in a study conducted by Grunwell and Harding (1996), where they suggested that a small amount of air might be leaking into the nasal cavity while adequate air is building up to result in audible plosion.

occurred in different tokens in word-initial position (i.e. /d/ →[d̺, n, n̼, dˤ]) – e.g. :

/ dawaːʔ/→[d˞ ãwa] ‘Medicine’

/dʊk.tɔrah/→[nʊn.nɔnah] ‘doctor’

/daradʒ/→[n̼an̼an̼] ‘stairs’

/dadʒaːdʒ/→[dˤãdˤãːl] ‘chicken’

An interesting range of replacements occur for the trill /r/. It is sometimes glided in word-initial position (e.g. /**r**ɪ.dʒaːl/ →[**w**an̼aːn̼] ‘man’) and this is considered to be a normal phonological development (Ayyad, 2011). However, it was occasionally replaced by a weakly produced emphatic in word-medial position (e.g. [θãj.jãːd̺ˤah] for /saj.jaːrah/ ‘car’). In fact, substitution of emphatic ([dˤ] or [tˤ]) for the trill has been noticed to occur in many tokens other than the target single words in the GOS.SP.ASS. Such replacements are unusual and have not been reported in the literature. In addition to the use of weak emphatics for the target trills, Saud sometimes used a nasal realisation instead of /r/. Examples of emphatic and nasal realisations of /r/ are presented in Table 9-5.

Table 9-5 Saud’s trill production: sample single word productions containing /r/

Emphatic realisation of /r/			**Nasal realisation of /r/**		
Cucumber	/χɪjaː**r**/	[ħɪjaː**t˞** ˤ]	Sheep	/χa**r**uːf/	[ħa**m**u]
Car	/saj.jaː**r**ah/	[θaj.jãː**d˞** ˤah]	Doctor	/dʊk.tɔ**r**ah/	[nʊn.nɔ̃**n**ãh]
Plane	/tˤaj.jaː**r**ah/	[ðaj.jãː**d˞** ˤah	Giraffe	/za**r**aːfah/	[ʔa**n**ãːnah]
His back	/ðˤah.rah/	[ðˤãh.**d˞** ˤãh]	Monkey	/qɪ**r**d/	[n̼ɛ**n̼**ʰ]

9.2.4 Conclusion of Saud case study

Saud’s speech could be described as: Fairly consistent, limited accurate realisation in both single words and sentences, more consistent productions in single words than sentences.

Generally, consistent patterns of nasal realisations were noted more in sentences than single word productions across contexts. Thus, in sentences the child tends to use the same realisations for the target segment in almost all word positions, whereas in single word productions inconsistency was noticed to occur the most in word-initial position followed by word-final position. On the other hand, in both elicitation modes, inaccurate productions were noted in almost all of the target segments except for nasals, pharyngeal and glottals.

In terms of variability, differences were more evident in word-initial position, word-final and then word-medial position respectively. This is inconsistent with findings of a Jordanian study on typically developing Arabic children (Amayreh, 1998) where he found that children tend to gradually develop consonants gradually, first in word-medial position and then in word-initial and final positions.

m n n̰ m̥ b d d̥ˤ tˤ w w̰ θ θ̰ j ʔ ħ ʕ	**m** m n n̰ m̥		**n** n		Word-initial position						
		b m b	**t** w̰	**d** d̚ n n̰ dˤ		**k** n n̰		**q** n̰ d ʔ	**tˤ** ð	**dˤ** n̰	**ʔ** ʔ
	f n̰ d tˤ		**θ** θ	**ð** ʔ	**ʃ** n n̰ / **dʒ** n̰ d̚ d̥ˤ j	**χ** ħ	**ʁ** ʕ		**ðˤ** ðˤ	**ʕ** ʕ	
			s θ θ̰ n̰	**z** ʔ					**ħ** ħ	**sˤ** n n̰	
	w w		**r** w ɾ (r) **l** n l		**j** j	**h** h					

m b̚ n n̰ d̥ˤ dˤ tˤ l w j ʔ ħ ʕ d̃	**m** m		**n** n̰		Word-medial position						
		b m m̰ b̚	t n	**d** d̃ n n̰		**k** n̰		**q** n n̰	**tˤ** n̰ dˤ	**dˤ** n	**ʔ** ʔ
	f n n̰		**θ** n̰	**ð** n̰	**ʃ** n / **dʒ** n̰	**χ** ħ	**ʁ** ʕ		**ðˤ** d̚ d̥ˤ	**ʕ** ʕ	
			s n n̰	**z** d̥ˤ					**ħ** h	sˤ d̃ n̰	
	w w		**r** dˤ n n̰ tˤ l **l** n̰ dˤ n		**j** j	**h** h̚					

mʰ m̥ b̚ n nʰ n̰ n̰ʰ tˤ d̥ˤ l lʰ i ħ ʕ ʔ	**m** mʰ		**n** n nʰ (n)		Word-final position						
		b m̥ (b) b̥	**t** ( )ʰ	**d** (d) n̰		**k** lʰ		**q** ʔ	**tˤ** n̰	**dˤ** d̥ˤ	**ʔ** ( )
	f (f)		**θ** n̰	**ð** n	**ʃ** l / dʒ n̰ l	**χ** ħ	**ʁ** ʕ		**ðˤ** - -	**ʕ** ʕ	
			s ( )ʰ n̰	**z** nʔʰ					**ħ** ħ	sˤ d̥ˤ	
	w --		**r** n n̰ tˤ (r) l l n̰ʰ		**j** i	**h** h					

Figure 9-2 Saud's System of Contrastive Phones and Contrastive Systems

9.3 Saad

Saad was chosen as one of the individual case studies because variability was not only identified in his speech production according to different word positions but also, significantly, across the different clinical tasks. As with Nasreen and Saud, above, three different analyses will be presented: single words and sentence repetition (using the consonant production table of GOS.SP.ASS framework) as well as PACS (System of Contrastive Phones and Contrastive Systems).

9.3.1 Single word production

Table 9-6 Saad's speech production:

An analysis using the GOS.SP.ASS consonant chart, based on single word data

Single words	**Labial**			**Dental**		**Alveolar**							**Post-alveolar**		**Velar**
Target	**m**	**b**	**f**	**ð**	**θ**	**n**	**l**	**t**	**d**	**s**	**Z**	**r**	**ʃ**	**dʒ**	**k**
Word Initial	m	b	f	d̼	θ	n	l̰	t̚	d̼	θ	ð	r	ɬ	d͡g	kʰ
Word Medial	m	b̚	f	d	θ	ŋ	l	t	d	ɬ͆	ð	ɾʷ	ç	dʒ	k
Word Final	m	p'	(-)	s	θ	n	lʰ	h	(-)	ɬ͆	ʔɬ͆	(-)	ɬ	gʰ	k̚ʰ

Single words	**Emphatics**				**Uvular**			**Pharyngeal**		**Glottal**	
Target	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**
Word Initial	θ	d	t͡q	dˤ	ʁ	χ	g	ħ, h	ʕ	h	ʔ
Word Medial	ɬ͆	ðˤ	dˤ, tˤ	dˤ	ʁ	x	g	ħ	ʕ	h	ʔ
Word Final	θ	ðˤ	ʔ	…	ʁ	χ	g̚	ħ	ʕ	h	( )

Table 9-6 presents consonant data from Saad’s single word productions which show a mixture of intact consonant productions as well as the occurrence of errors related to a history of cleft palate. Furthermore, some of his realisations occur either as acceptable socio-phonetic variants or as typical phonological developmental variants, as in the case of alveolar fricatives. In addition to these realisations, other realisations also occur including Saad’s use of bilabial ejectives for bilabial plosives in the word-final position. Saad’s single word data will be described starting from the most frequent cleft realisations moving to the least frequently occurring realisations. Developmental realisation as well as acceptable variants will also be addressed in this section.

9.3.1.1 Cleft palate realisations

In terms of cleft palate errors, the most noticeable feature in Saad’s speech is lateral fricatives which occurs where ‘the primary target airstream is central’ but at the same time air is escaping laterally to one or both sides of the tongue (Sell *et al.*, 1999). As reported by Grunwell (1987) and Harding and Grunwell (1998) the lateral fricative is one of the frequent occurring replacements for target central fricatives (see section 7.5.1.3). Saad used lateral realisations for the alveolar and postalveolar targets /s, z, ʃ/ as well as the emphatic /sˤ/. Additionally, he sometimes used an interdental production of the lateral alveolar fricative (e.g. /s/ →[ɬ̪͆]), which could be a cleft palate error occurs concurrently with a developmental error.

As with many children in this study (Chapter 7), Saad frequently deletes consonants word finally or occasionally uses glottals /ʔ, h/ as replacements for the target segment in word-final position. Velar backing was evident in one occasion as Saad substituted the entire affricate with an aspirated velar plosive (/dʒ/ →[gʰ]).

Double articulation was evident twice in Saad's speech; once as a replacement for the affricate (i.e. /dʒ/→ [d͡g]) and the second occasion occurred for the target alveolar plosive in word-initial position (i.e. /tˤ/→ [t͡q]). As described in the literature, double articulation usually occurs as a difficulty in producing a consonant through a single contact and thus makes a two points of contact between the tongue and the palate. Arabic emphatics are, in fact, produced with the use of primary and secondary articulations. The primary articulation involves an anterior tongue stricture, whereas secondary articulation involves retraction of the tongue body into the oropharynx (Bin-Muqbil, 2006). In this example, it could be hypothesised that the child achieved the primary articulation by using the tongue tip for /t/ but for the secondary articulation he failed to retract the tongue body into oropharynx appropriately, instead making tongue contact at a uvular place of articulation, thus creating a double articulation. In word-medial position, Saad produced /tˤ/ correctly in one target word (i.e. /ʕɛtˤɛr/ →[ʕɛtˤɛ̃N] 'perfume' but used its voiced counterpart in another word (i.e. /matˤar/→[madˤaɾ] 'rain'). In word-final position, he replaced the target emphatic with glottal stop.

For the velar stop, Saad can produce it accurately followed by aspiration. However, for the target word /kɪtaːb/ 'book' the child produced /k/ as [ʔ] (thus [ʔɛn̥̆.taːp']) for his first attempt, but when asked to repeat the same word, he used self-correction and thus produced [kʰɛt̆aːp'] as a second production. It is suggested that Saad replaced the velar stop with glottal stop .For the second production (i.e. [kʰɛt̆aːp']), the child could produce an aspirated velar [kʰ].

For the segment /t/ in the same target word /kɪtab/ 'book', the child used nasal emission as a replacement (nasal fricative [n̥̆]) for the first attempt and thus became [ʔɛn̥̆.taːp']). For the second production, a persistent occurrence of nasal emission was also evident for the alveolar stop but, this time, occurs as an accompanier rather than a replacer [kʰɛt̃a:p’]). Nasal emission is an audible escape of air from the nasal cavity and occurs as possible consequence to the presence of velopharyngeal incompetence or a palatal fistula. As with the mentioned examples, it is possible for the nasal emission to accompany the consonant or to replace it. When the latter occurs, it is classified as nasal fricative (Sell *et al*., 1999).

An additional unusual feature reported in Saad’s speech was the occurrence of bilabial ejectives word finally for target bilabial plosives /kɪtab/→[kʰɛt̃a:p’]. Such a pattern has not been reported previously in the literature except for a single study conducted by Al-Awaji (2008) on four Saudi children with cleft palate, where she reported one of the children using velar ejectives as a replacement for /r/ word finally (for instance, [fa:k’] for /fa:r/). In this study ejectives have been reported in a number of children (see section 7.6.1). It could be hypothesised that the use of ejectives is an active error which develop as a learned compensatory strategy related to the physiological constraints initially, but which may persist after the structural defect has been corrected (Peterson-Falzone *et al*., 2001).

9.3.1.2 Developmental and acceptable realisations

The only evident developmental phonological realisations in Saad’s data affect alveolars: the fricatives /s, z/, emphatics /sˤ, dˤ/ and the trill /r/. Saad tends to use a dental place of articulation for /s, z, sˤ/ which can be considered as normal phonological development. Sometimes, for example, he used a dental variant for the target alveolar fricative, thus showing a more typical developmental pattern (e.g. /s/ →[θ]). This is shown in the target single word /sɪj.ja:rah/→[θɪj.jã:wah] ‘Car’. In addition, as mentioned above, he accompanied the dental articulation with the realisation of lateral cleft type error (e.g. /sˤ/→[ɬ͆])). For the emphatic /dˤ/, Saad simplified it once by using its non-emphatic counterpart [d]. Furthermore, a glide was reported once accompanying the production of tap [ɾʷ] and this occurs as a replacement for /r/. Gliding was reported by Ayyad (2011) as one of the patterns observed as a normal phonological development of Arabic where she referred to it as ‘coronal glide’.

In terms of acceptable socio-phonetic variants, these are consonants that are also used by adult as a typical realisation in the variety of Arabic spoken by Saad. The acceptable variants in Saad’s single word data are /ð/ →[d], /dˤ/ →[ðˤ], and /q/→ [g].

9.3.2 Sentence repetition

Table 9-7 Saad’s speech Production:
An analysing using GOS.SP.ASS consonant chart sentence repetition data

Sentences	**Labial**			**Dental**		**Alveolar**							**Post-alveolar**		**Velar**
Target	**m**	**b**	**f**	**ð**	**θ**	**n**	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**k**
Word Initial	m	b	f	t	θ	ñ̼	l	t*	d	ɬ͆	n	ɽ	ç	d͡g	k
Word Medial	m̃	b	f	d̼	tʰ	ñ̼	l	t*	d	ɬ͆	n	w	ç	d͡g	k
Word Final	m̃	b	f	(-)	(-)	ñ̼	l	t̚	d̚	ɬ͆	ʔɬ	ɽ	ç	d͡g	k

Sentences	**Emphatics**				**Uvular**			**Pharyngeal**		**Glottal**	
Target	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**
Word Initial	ɬ͆	ð̃ˤ	t̃ˤ	ð̃ˤ	ʁ	χ	q	ħ	ʕ	h	…
Word Medial	ɬ	d̚ˤ	t̃ˤ	ð̃ˤ	ʁ	χ	g	ħ	ʕ	h	…
Word Final	ɬ	d̚ˤ	t̃ˤ	ð̃ˤ	ʁ	χ	g	ħ	ʕ	h	…

Table 9-7 presents target segment realisations from Saad's repetition of the GOS.SP.ASS sentences. Comparison of the GOS.SP.ASS sentence repetitions and the GOS.SP.ASS single words revealed the occurrence of similarities as well as differences. As with single word productions, the data from the sentence repetitions revealed the occurrence of lateral articulations and backing. However, additional patterns were also evident in sentence repetition data, including: nasal emission, nasal replacement, hypernasality and palatal fricatives. Thus, Saad's sentence repetitions were worse than the single word productions. In the coming section similarities as well as differences will be described as a comparison between single words and sentence repetitions data.

9.3.2.1 Cleft palate realisations

Similar patterns in both clinical tasks:

Lateral articulation was also evident in the sentence repetition data for the alveolar fricatives /s z sˤ/ but not for /ʃ/, which was realised as [ɬ or ɬ̪͆]. Specifically, Saad used dentalised lateral articulation for the target /s/ in all word positions in sentence repetition; however, in the single word data he used such replacements only in word-initial and word-final positions. As with the data from single words, target /z/ was only realised with a lateral articulation word finally. Interestingly, glottal insertion ([ʔɬ]) accompanied the lateral realisation of /z/ both in single words and sentence production data. For the glottal insertion [ʔɬ], the child might be trying to prevent the nasal realisation (found in word initial and word-medial positions) by producing a glottal stop followed by friction. For the emphatic fricative /sˤ/, Saad used a lateral fricative in all word positions; in word-initial position this lateral realisation was accompanied by dental articulation. By comparison, Saad used lateral replacement only in the word-medial position in the single word data.

As reported earlier, Saad also used a lateral fricative realisation for the postalveolar fricative in word-initial and word-final position. Word medially, however, he replaced the target segment with a voiceless palatal fricative [ç]. In the sentence repetition data, the child used a palatal realisation in all word positions. Gibbon and Hardcastle (1989) reported that excessive retraction of the tongue contact results in the air being directed either centrally (i.e. palatal articulation) or laterally (i.e. lateral articulation). As Saad is using both lateral and palatal fricatives, it could be suggested that he is, in fact, using lateralised fricatives and therefore the lateral escape of air is being used to produce [ls] (Sell *et al.* ,1994). The latter behaviour could be confirmed by the use of Electropalatography. As for single word data, Saad used double articulation in all word positions, thus /dʒ /→[d͡g].

Additional patterns in sentence repetitions data:

Additional features occurred in the sentence repetition data which had not been identified in the single word naming task. These include problems affecting resonance, i.e. hypernasality, hyponasality, nasal replacements, as well as nasal emission.

In terms of hypernasality, it mainly affected the production of emphatics (except for /sˤ/). However, in cases where there was not any hypernasality associated with the realisations of the emphatic, Saad tends to produce the target emphatic weakly, as with the emphatic /dˤ/in word-medial and word-final positions, which was realised as [d̦ˤ]. Furthermore, a slight degree of denasalisation was evident for the nasal targets. The combination of these three patterns suggests the occurrence of mixed nasality (Sell *et al.*, 1999) which can occur as a consequence of velopharyngeal insufficiency (Kummer and Lee, 1996).

As observed, there is an inconsistent occurrence of hypernasality. According to Sell *et al.* (1999), inconsistent resonance requires consideration especially when conducting therapy as optimal oral resonance could be achieved with intensive therapy sessions. While Saad used a developmental simplification for the voiced alveolar target in single words data (i.e. /z/→[ð]), in the sentence repetition data he replaced the target segment with a nasal realisation word initially and medially (i.e. /z/→[n]). As reported earlier, he used lateral fricative articulation to produce this target segment word finally both in single words and sentence repetition data.

Nasal emission was also evident in Saad's sentence repetition data but only for the alveolar plosive /t/ in word-initial and word-final positions. In comparison, in the single word data he produced the same target segment weakly word initially and accurately word medially. Linguolabial place of articulation was also noticed accompanying the production of alveolar nasal targets, a pattern which had not been identified in the single word data.

9.3.2.2 Developmental and acceptable realisations

Regarding the developmental errors in Saad's speech output, the sentence repetition data show less frequent occurrence of developmental simplifications in comparison to the single word data. Similar to the single word data, glide replacement was also evident in the sentence repetition and also in word-medial position. This was the only evident developmental replacement apart from the tendency to use dental articulation simultaneously with the production of lateral articulation for target alveolar fricatives. In terms of socio-phonetically acceptable variants, the only ones reported are for /dˤ/→[ðˤ], /ð/→[d] and /q/→[g].

To sum up the findings, Saad's speech profile indicates the occurrence of a number of different errors which are either related to a history of cleft palate or associated with phonological development. As can be clearly seen in Table 9-9, uvular, pharyngeal and glottal productions are intact in both the single word and sentence production data. Some of the cleft errors were evident only in the single word production data but not in the sentence repetition and vice versa. (e.g. ejectives, hyponasality).

9.3.3 PACS analysis

9.3.3.1System of contrastive Phones and Contrastive Assessments

Saad's contrastive system reveals a degree of consistency for most of his consonant productions across all word positions. Most observed variability occurred for alveolar targets including /t/, /d/, /s/. For instance, Saad realised /t/ in three different ways as shown in the following examples:

/mif.taːħ/→ [mɛf.taːħ] 'Key'

/kitaːb/→[kɛt͋aːp'] 'Book'

/duk.tuːrah/→[d̪at͌. t͌uwah] 'Doctor'

Thus, the child produced the target /t/ accurately in the first example, however he used nasal emission in the second word and turbulence in the third example. Further inconsistent productions were revealed for the target /s/ as Saad sometimes produce it as a dental fricative (i.e. [θɪj.jaːwah] for /sɪj.jaːrah/ 'car') which would be considered to be a typical developmental simplification. However, a lateral fricative articulation was used for a different token of the same word: i.e. [ɬɪj.jaːwah]. Interestingly, he used dentalisation along with lateral articulation in a third word /sʊl.ħafah/ [ɬ͆ʊl.ħafaʔ] 'Turtle' .

9.3.4 Conclusion of Saad's case study

Although Saad's productions of consonants were inconsistent in both single words and sentence repetition sampling conditions, realisation of sentences showed a better consistency compared to single words. On the other hand, productions of segments were more accurate in single words than sentences.

Throughout the data, variability was more evident in word-final position both in single words and sentences. It could be suggested that the variable productions of consonants in word-final position is part of phonological process where children tend to acquire word-initial and word-medial positions before consonants word finally(Stoel-Gammon, 1987).

m n b t̡ d̰ dˁθ f w r l l̰ h kʰ ʔ k̃ ʕ ɬ⊓ ð ʁ ħ q g ɬ	**m** m		**n** n		Word-initial position							
		b b	**t** t̡	**d** d̰ dˁ			**k** kʰ ʔ k̃		**q** q g	**tˁ** t͡q	**dˁ** dˁ	**ʔ** ʔ
	f f		**θ** θ	**ð** d̰	**ʃ** ɬ ʃ	**dʒ** dg	**χ** χ	**ʁ**ʁ		**ðˁ** dˁ	**ʕ** ʕ	
			s θ ɬ⊓ ɬ	**z** ð						**ħ** ħ h	**sˁ** θ ɬ⊓	
	w w		**r** r l l̰		**j** ʔ (acc [ʔid])		**h** h					

m ŋ b̡ b t˜ t̃̃ t̃̊ θ d ɬ⊓ ð rʷ w ɾ h l l ʟ dʒ g t̡ˁ tˁ dˁ t̡ˁ dˁħ	**m** m		**n** ŋ		Word-medial position							
		b ḅ b	**t** t˜t̃̃ t̃̊	**d** d̰ d dⁿ			**k** k		**q** g	**tˁ** tˁ dˁ t̡ˁ	**dˁ**ðˁ	**ʔ** ʔ
	f f̃̊		**θ** θ	**ð** d	**ʃ** ç	**dʒ** dʒ g	**χ** x	**ʁ**ʁ		**ðˁ** dˁ	**ʕ** ʕ	
			s ɬ⊓	**z** ð						**ħ** ħ	**sˁ** ɬ⊓	
	w w		**r** rʷ w ɾ h l l ʟ		**j** j		**h** h					

m n pʼ d θ k̡ʰ ðˁħ h l l̡ʰ g gʰ k̡ʰ g̡ ʔ ɬ⊓ ɬ x χ	**m** m̥		**n** n		Word-final position							
		b pʼ (b)	**t̥** ñ̃ h	**d** d (d)			**k** k̡ʰ		**q** g̡	**tˁ** ʔ	**dˁ** ðˁ	**ʔ** ( )
	f (f)		**θ** θ	**ð** s	**ʃ** ɬ	**dʒ** g gʰ	**χ** χ	**ʁ** x		**ðˁ** __	**ʕ** ʕ	
			s ɬ⊓ ɬ	z						**ħ** ħ	**sˁ** θ	
	w --		**r** ( ) l l̡ʰ (l)		**j** i		**h** h					

Figure 9-3 Saad's Systems of Contrastive Phones and Contrastive

9.4 Shoog: Phonological consequences of different patterns

For the fourth case study, a child with highly variable speech output has been chosen. Harding-Bell and Howard (2011) discuss inter-speaker variation, which describes the different and creative responses of each individual to the articulatory and perceptual difficulties encountered by the structural abnormality related to cleft palate versus intra-speaker variation, which describes cases where an individual speaker may realise a target segment in several different ways.

A number of different cleft speech patterns have been identified in Shoog's speech including cleft backing, active nasal fricatives and/or plosives, nasal turbulence, hypernasality, weak articulation and double articulation. Shoog's speech data provide one of the best examples of highly variable data from the whole group of participants, as different realisations can be identified for a single target segment in different word positions and in different tokens of the same word.

Shoog's speech output will be described from three perspectives: target segments in single words and sentence repetition using the consonant production table of the Saudi Arabian GOS.SP.ASS, and all tokens of all sounds, using the PACS System of Contrastive Phones). In each clinical task, variable patterns have been described and comparisons were made of the differences observed in relation to the clinical task. PACS has also been used to explore segmental variability in her speech production.

9.4.1 Single word productions

Table 9-8Shoog’s speech production:

An analysis using GOS.SP.ASS consonant chart single words data

Single words	Labial			Dental		Alveolar							Post-alveolar		Velar
Target	**m**	**b**	**f**	**ð**	**θ**	**n**	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**k**
Word Initial	m	ʔ	n̥͌	ŋg	n̥͌	n	l	n̥͌	ŋ	n̥͌	n̥͌	ɾ	n̥͌	n̥͌	k
Word Medial	m	b̚	f	ð	-	ŋ	l	t	d̪	n̥͌	ð͌	r	ʃ͌	d͌.g	k
Word Final	(-)	b̚	(-)	g	θ͌	n	ʔ	(-)	d̪	θ͌, ñ̥	ñ̥	(-)	θ͌	d̚ ñ̥ , g͡ʔʰ	k

Single words	Emphatics				Uvular			Pharyngeal		Glottal	
Target	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**
Word Initial	θ͌, n̥͌	ŋ	tˤ	ŋ	ʁ	x̣ n͌g	ʁ	ħ	ʕ	h	ʔ
Word Medial	θ	ðˤ̚	q	ð̣͌	ʁ͌	x	ʁ͌	ħ	ʕ	h	ʔ
Word Final	n̥͌	q	(-)	…	ʁ	x	ʁ	ħ	ʕ	h	--

As with the Nasreen, Saad and Saud, three aspects will be considered when describing Shoog’s data in single word productions, that is; different cleft type characteristics, individual variations in terms of realisation of the target segment as well as developmental realisations.

9.4.1.1 Cleft palate realisations

In terms of cleft type characteristics, the most prominent feature is the occurrence of nasal fricatives and/or plosives in which the air is forcefully directed nasally so that what can be heard is nasal turbulence, giving, nasal fricative production of the target segments i.e. /f, t, θ, s, z, r, dʒ, sˤ, ʁ/ were realised as [ñ̥]. In the current study, nasal fricatives and/or plosives have been identified in a number of children (see sections 7.5.1.7 and 7.5.1.8) and Shoog is one of the participants who use these patterns frequently. In addition, nasal turbulence occurred as an accompanier rather than a replacer for some target consonants (see Table 9-8).

Another pattern observed in Shoog's speech is cleft backing which is, as reported in the literature, considered to be the most frequently occurring phonological process in children with cleft palate. In the single word data, Shoog used uvular place of articulation for the segments /ð,dˤ,tˤ/ though, as in many children in this study, not consistently in all of the word positions.

An interesting pattern was noticed in some realisations of the target segments /ð, χ/. For these fricatives, Shoog used a nasalised plosive realisation or a nasal fricative followed immediately by the production of velar stop (i.e. /ð/→[ŋg], /χ/→[ñg]). This could be a strategy adopted by her to minimise the nasal turbulence by producing nasal followed immediately by plosive. However, for some plosives, she used nasal replacement solely /d, dˤ, ðˤ/→[ŋ]. All of these replacements occur only in word-initial position. In addition to the above mentioned patterns, hypernasality and weak articulation were also evident in some of the segments including: /b/ →[b˺], /d/ →[d˺], /ðˤ/ →[ð˺].

What is noticeable in general is that most of the oral consonants in Shoog's word productions are affected by the presence of cleft palate so that most of her realisations are directed nasally, retracted posteriorly or produced weakly. One suggestion is that Shoog might have an undiagnosed fistula which is restricting her production and the backing process indicates that the VP is functioning but not properly (Harding and Grunwell 1998).

9.4.1.2 Developmental realisations

Fewer realisations related to phonological development were found in Shoog’s speech when compared with cleft palate realisations. The only noted pattern is dental articulation for the alveolar and postalveolar targets including /s, z, ʃ/,however, nasal turbulence is also realised along with the production of these consonants (e.g. /s/→ [θ͌]). Acceptable realisations also occur for /**q**/→[**g**] only in word-medial position.

9.4.2 Sentence repetitions

Table 9-9Shoog’s speech production:

An analysis using GOS.SP.ASS consonant chart sentence repetition data

Sentences	**Labial**			**Dental**		**Alveolar**							**Post-alveolar**		**Velar**
Target	**m**	**b**	**f**	**ð**	**θ**	**n**	**l**	**t**	**d**	**s**	**z**	**r**	**ʃ**	**dʒ**	**k**
Word Initial	m	q	ŋ̥͌	g̚˜	θ̚	n	l	q	d̚ ʰ	ŋ̥̃	ŋ̥̃	ɾ	ŋ̥͌	ð͌̚	q
Word Medial	m	g	ŋ̥̃	g̚˜	θ͌	n	l	q	q	ŋ̥̃	ŋ̥̃	( )	θ͌	d͌̚g	k
Word Final	m	g	ŋ̥̃	(-)	θ͌	n	l	(-)	q	ŋ̥̃	ŋ̥̃	ɾ	θ͌	d͌̚g	g

Sentences	**Emphatics**				**Uvular**			**Pharyngeal**		**Glottal**	
Target	**sˤ**	**dˤ**	**tˤ**	**ðˤ**	**ʁ**	**χ**	**q**	**ħ**	**ʕ**	**h**	**ʔ**
Word Initial	ŋ̥͌	ŋ̥͌	tˤ≈	__	ʁ͌	x̣	g	ħ͌	ʕ	h	…
Word Medial	ŋ̥͌	g^{n}	q͌	__	ʁ≈^{g}	x^{n}	g	ħ	ʕ	h	…
Word Final	ŋ̥͌	(-)	(-)	…	g	( )	g	ħ	ʕ	h	…

9.4.2.1 Cleft palate realisations

Nasal turbulence affects a number of target segments by either accompanying (e.g. /θ/→[θ͋]) or in the severe cases replacing (i.e. nasal fricatives (e.g. /s/ →[n̥͋]) and/or plosives (e.g. /dˤ/→[n̥͋])). As with single word productions, alveolar fricatives were produced as nasal fricatives. Other segments /f, θ, ʃ, dʒ, sˤ, dˤ, tˤ, ʁ/ were also affected by nasal turbulence that is either accompanying (i.e. nasal turbulence) or replacing the consonants (nasal fricatives and/or plosives) .

Segmental variability was observed when comparing the realisation of segments across the different clinical tasks. For example, although the voice bilabial plosive /b/ was produced either accurately or weakly in single word productions, Shoog applied a cleft backing process for this target consonant in all word positions in the sentence repetition data. Moreover, differences between the two clinical tasks also occur in realisations of the target sound /d/, which she produced nasally or weakly in the single word productions but using a backing process in word-medial and word-final position in the sentence repetition data. Interestingly, some segments (e.g. /t/) are replaced by nasal fricatives in single words production but posterior placement occurred in the sentence repetition data. As reported earlier, the child might have a fistula affecting production of the targets (i.e. occurring of nasal fricatives), which might explain the child's nasal fricatives in single word productions for e.g. /t/. In terms of the posterior placement that occurs in sentence repetition, it is suggested that Shoog was trying to mimic the examiner production by occluding the fistula by her tongue to prevent the production of turbulence and thus the backing process occurred inevitably.

Furthermore, Shoog used either velar or uvular cleft backing for other plosives such as /t, dˤ, tˤ, k/ and fricatives /ð, ʁ/ and all of these occur inconsistently in different word positions of sentence repetition data. For /ʁ/ in word-medial position she produced the sound along with the realisation of nasal turbulence and followed immediately by production of voiced velar plosive [ʁ̃ᵍ]. She also backed /dʒ/ in word-medial and word-final positions but only for the second half of the segment (i.e. /dʒ/ →[d̪̃g]) along with the realisation of nasal turbulence. Similarities, however, have also been observed among both clinical tasks (single words and connected speech) in which nasals and approximants were not markedly affected.

Based on Shoog's speech profile, it is suggested that she might have an undiagnosed fistula (hypernasality and weak articulation) which is restricting her production and the backing process indicates, as Harding and Grunwell, (1998) suggested, "the presence of some VP function" which means that the VP is functioning but not properly. Thus, in Shoog's case it could be predicted that she would benefit from surgical intervention to close the fistula (if present) and speech therapy sessions to correct the backing process.

9.4.2.2 Developmental realisations

The only developmental simplification noted is for the affricate in word-initial position where she produced it as a dental fricative, along with the realisation of nasal turbulence (i.e. /dʒ/ →[ð̪̃]), thus losing place and manner features. According to the study of Amayreh and Dyson (1998), the affricate is one of the consonants that pose an articulatory difficulty and therefore tends to develop very late (after 6; 4). Thus dental fricative realisation of target postalveolar affricate is normal developmentally, however the production is affected with nasal turbulence as a result of cleft palate. Acceptable realisations occur here for /**q**/→[**g**] in all word positions.

9.4.3 PACS analysis

9.4.3.1 System of Contrastive Phones and Contrastive Systems

I. Word-initial position

As recorded in Figure 7.4 there is variability in the different phones recorded for several target segments including /b, f, t, d, ʃ, ʤ, χ, ðˤ, sˤ/. For example, Shoog realised the target sound /ʤ/ with nasal turbulence in a single word token but differently in other tokens. This is shown in the following examples:

[ñ̥̰ãlɪṅ̥̰]	/dʒalɪs/	'sitting'
[ðʊb̹.næh]	/dʒʊb.næh/	'cheese'
[ʤ̰̃ æræñ̥̰]	/dʒ æræs/	'bell'
[ŋɡæɾæñ̥̰]	/dʒæræs/	'bell'

Thus nasal turbulence affects Shoog's production of /ʤ/. When the turbulence is absent, she used a velar nasal realisation followed immediately by the production of a homorganic voiced plosive [ŋɡ]. As suggested previously, this could be an approach utilised by her to reduce the nasal turbulence by producing nasal followed immediately by velar stop. The latter behaviour is shown above in the last two examples where the child realised /ʤ/ in the same word on different occasions.

II. Word-medial position

Less variability is observed for word-medial targets when compared to word-initial. Most of the differences in realisation occurs for anterior sounds [25]including the bilabial stop, labiodental fricative /f/ and some of the alveolar targets /t, d, s/. For these targets, Shoog either produced them

[25] Anterior sounds involve labials ,dentals ,alveolars

weakly (e.g. [b̹, d̹])' accompanied the oral realisations with nasal turbulence or used a more posterior place of articulation. For posterior sounds[26], there is not any variability or overlapping in the child system.

III. Word-final position

Segment production in word-final position does not differ much from word-medial productions except that Shoog shows an occasional tendency to delete segments word finally or produce them weakly. A general observation applied for segments in all word position is that posterior sounds are less vulnerable, especially pharyngeals and glottals.

9.4.4 Conclusion of Shoog case study

Similar to Saad, Shoog's realisations of sentences were more consistent compared to single words. However, her productions of segments are more accurate in single words than sentences.

Also, variability was more evident in word final position both in single words and sentences and this is similar to the speech performance of Saad.

[26] Posterior sounds involve palatoalveolars, palatals, velars, uvulars, pharyngeals.

Word-initial position

m n ñ̥̃g ʔ q g ñ̥̃ ɾ ñ̥̃ ŋ l j θ̃̃ ŋg ħ	**m** m		**n** n									
		b (b)ʔ ñ̥̃g ʔ q g	**t** ʔ ṅ̥	**d** ŋ d̚ d̚͡g			**k** k		**q** q g	**tˁ** tˁ	**dˁ** ŋ	**ʔ** ʔ
	f ñ̥̃ ṅ̥		**θ** ñ̥̃	**ð** ŋg	ʃ ñ̥̃ θ̃̃	**ʤ** ñ̥̃ ð̃̃ ʤ̃̃ ŋg	**χ** ñ̥̃g χ	**ʁ** ʁ		**ðˁ** ŋ ð̚ ˁ ñ̥̃	**ʕ** ʕ	
			s ñ̥̃	**z** ñ̥̃						**ħ** ħ	**sˁ** ñ̥̃ θ̃̃	
	w w		**r** ɾ ñ̥̃ ŋ **l** l		**j** j		**h** h					

Word-medial position

m ŋ b̚ g nq ñ̥̃ g f̃̃ w r ŋ ɾ l l θ̃̃ ð χ̚ d≈ ɡ g h ð̃̚	**m** m		**n** ŋ									
		b b̚ g nq	**t** t q	**d** d̚ q qŋ			**k** k		**q** g	**tˁ** q	**dˁ** ðˁ̚	**ʔ** ʔ
	f ñ̥̃ g f≈		**θ** θ̃̃	**ð** ð	**ʃ** ʃ̃̃	**ʤ** d≈ ɡ	**χ** χ̚	**ʁ** ʁ̃̃		**ðˁ** ð̚	**ʕ** ʕ	
			s ñ̥̃ θ	z ð≈						**ħ** ħ	sˁ θ̃̃	
	w w		**r** r ŋ ɾ l l		**j** j		**h** h					

Word-final position

n b̚ d̚ d̃̃ θ̃̃ ng θ̃̃ ñ̥̃ r ʔ d̚ ñ̥ , g͡ʔʰ ʁ q χ̚	**m** (m)		**n** n									
		b b̚ (b)	**t** (t)	**d** d̚ d̃̃			**k** k		**q** q	**tˁ** ( )	**dˁ** q	**ʔ** ( )
	f (f)		**θ** θ̃̃	**ð** ng	**ʃ** θ̃̃	**ʤ** d̚ ñ̥ ,g͡ʔʰ	**χ** χ	**ʁ** ʁ̚		**ðˁ** _	**ʕ** ʕ	
			s θ̃̃ ñ̥̃	**z** ñ̥̃						**ħ** ħ	**sˁ** ñ̥̃	
	w _		**r** r ( ) **l** ʔ		**j** i		**h** h ( )					

Figure 9-4 Shoog's Systems of Contrastive Phones and Contrastive

9.5 Discussion

To illustrate and exemplify inter- and intra-speaker variability, four children with cleft palate were chosen (Nasreen, Saud, Shoog and Saad). Each child presented with a different profile caused by the structural abnormality related to cleft palate and phonological processes which occur as a normal phonological development.

In comparison with the other three children (Saud, Saad and Shoog), Nasreen's speech production demonstrated the least variability as she was using glottal realisations almost consister Word-medial position ctions of weak consonants and nasal realisation of plosives. All of these patterns emerged as a response of having velopharyngeal inadequacy (Harding and Grunwell, 1998).

Saud's speech profile on the other hand, is one of the interesting examples of intra-speaker variability occurring in children with cleft palate. Thus, along with the realisation of different patterns, including pervasive occurrence of nasal realisations, glottal stop, he also used unusual replacements for the trill (i.e. /r/→[$d^{ʕ}$, $t^{ʕ}$] and sometimes replaced the trill with nasals The latter reflects the creativity of individual's with cleft palate in dealing with the structural abnormality.

Saad was also chosen as one of the case studies where variability was noted in the form of different realisations occurring in single words rather than connected speech. Thus, sentence repetitions were worse than the single word productions. The last case study is Shoog, where most of her oral target segments are affected and thus directed nasally, produced posteriorly or weakly.

The phonetic variations of Nasreen and Saud showed that they were more consistent in comparison with Saad and Shoog. Consistent speech does not mean than Nasreen and Saud have more typical speech output than Saad and Shoog but rather because the range of speech sounds they had was much smaller than that for Saad and Shoog. It could be suggested that the glottal articulation in Nasreen's case and nasal realisation of Saud's case and their limited phonetic repertoire is caused by fluctuated conductive hearing loss and/or the presence of VPI (Donahue, 1993; Harding and Grunwell, 1998; Shriberg *et al*., 2003).

On the other hand, from a developmental speech motor viewpoint, the increased variability in Saad and Shoog speech output might be related to the emergence of new behaviours (Tyler and Saxman, 1991; Tyler and Edwards, 1993; Forrest *et al.*, 1994), whereas decreased variability overtime reveals a maturing speech motor system (Kent and Forner, 1979; Sharkey and Folkins, 1985).

As revealed from this chapter, children showed different performances on different elicitation modes. That is, both Nasreen and Saud had similar inaccurate productions in single words and sentences, whereas Saad and Shoog had more accurate speech in single words than sentences. The tendency of latter children to produce single words more accurately is concomitant with Howard's (2013) finding where she reported that one of the children studied exhibited his best speech performance in the single word elicitation condition in comparison with the sentence repetition sampling mode.

9.6 Conclusion

The chapter described inter-speaker and intra-speaker variability based on the speech production of four children with cleft palate. The phonological analysis of the four case studies revealed how children are creative in terms of compensating for the structural constrains related to cleft palate. This appears by individual differences in terms of using different phonetics conditioned by contexts and modes of elicitations. Variability of speech production observed among the four case studies is not unusual for individuals with cleft palate (e.g., McWilliams, 1958; Spriestersbach *et al.*, 1961; Van Demark, 1969; Kuehn and Moller, 2000; Klintö, *et al.*, 2011; Howard, 2013). Thus, phonetic variability in the speech of the children with cleft palate was common.

It can be suggested that the findings of the current study might support the observation that atypical speech production features, related to cleft palate, that are originally articulatory in nature may lead to phonological atypicalities (e.g., Grunwell and Russell, 1988; Chapman, 1993; Russell and Grunwell, 1993; Howard, 1993; Grundy and Harding, 1995; Harding and Grunwell, 1996; Bzoch, 1997; Harding and Howard, 2011). Thus, intervention plan needs to entail detailed knowledge of the phonetics of speech production and phonological patterns associated with cleft palate.

Chapter 10 **Discussion**

10.1 Introduction

This chapter addresses the research questions posed in Chapter 6 and the results reported in Chapters 7, 8 and 9. It explores the phonological processes demonstrated in the typically developing children and children with cleft palate (please see the details of the two groups in Chapter 6). The features of speech production identified in Arabic speaking children with cleft palate from previous cleft studies reported in Arabic and speech production related to cleft palate in other languages is also discussed and the cross-linguistic similarities and differences in terms of language-general versus language-specific findings of cleft-related speech processes are addressed. The chapter concludes with a discussion of the effect of the age of assessment and timing of cleft repair and cleft type on speech production in children.

These issues are investigated in relation to the research questions:

- Research Question 1 (Chapter 7): What are the speech development patterns found in typically-developing children and children with cleft palate in Arabic; and how do the results of this study relate to findings in other studies?
- Research Question 2 (Chapter 7): What are the cleft speech features found in the speech of the Arabic children with cleft palate and how they are related to findings in other languages? Are there any patterns which have not previously been reported in the literature?
- Research Question 3 (Chapter 8): Overall, are voiced segments more affected than voiceless segments?
- Research Question 4 (Chapter 8): Which are the most and least accurately produced consonants in cleft speech in Arabic-speaking children, and how do the results of the current study relate to previous findings?

- Research Question 5 (Chapter 8): What are the most and least affected manners/places of articulation and how are these related to findings of previous studies?
- Research Question 6 (Chapter 8): How is age of participants, age at repair and cleft type related to their speech production and how is this related to findings of previous studies?
- Research Question 7 (Chapter 9): Is there any significant inter- or intra-speaker phonetic and phonological variability observable in the data and if so, is it conditioned by word position and/or elicitation mode?
- Research Question 8 (Chapters 7, 8, 9): What are the clinical implications of the identified speech production features?

To answer the above questions, the chapter is divided into four parts: The first part summarises and discusses phonological processes identified in the two groups of children (details of the 21 children with cleft palate and four typically-developing four-year-old controls recruited in the study were given earlier in chapter 5, Tables 5-1, 5-2 and 5-3). It considers how the patterns found in the study are related to patterns found in Arabic studies and other languages.

The second part compares cleft speech characteristics found in the current study with those reported in Arabic cleft studies and studies on other languages. It covers voiced and voiceless segments; most and least accurately produced segments; segmental production in relation to age at assessment, age at repair and cleft type; comparisons of most and least accurately produced manner and place of articulation, and inter- and intra-speaker variability. In the third part, clinical implications of the study are discussed. The fourth and final part provides a conclusion, a summary of limitations of the present study and suggestions about future study directions.

10.2 Phonological processes

10.2.1 Phonological processes in typically-developing Arabic-speaking children (Control group)

This section addresses the first research question:

What are the speech development patterns found in typically-developing children; and how do the results of this study relate to findings in other studies?

As reported in Chapter 7, this study aimed to identify the phonological patterns found in the speech of typically-developing four-year-olds (i.e. the Control group), in order to generate normative data against which to compare the cleft speech data. In common with typically developing children in other languages, the control group demonstrates simplifications such as stopping, non-cleft dentalisation and postalveolar fronting, as well as a limited occurrence of structural simplifications, including assimilation and final consonant deletion. It must be noted, however, that the control group only consisted of four children: a larger group would have been preferable in order to draw stronger generalisations from the data.

Interestingly, stopping of alveolar fricatives and postalveolar fricatives, which is a common developmental process in many languages including English, Hungarian, Japanese, Korean, Turkish and Putonghua (Modern standard Chinese), as reviewed in Chapter 7 above (section 7.8.1), was not found in the speech of the control group of this study. The only instance of stopping occurs in just one child of the control group for the uvular fricative in word-medial position (/ʁ/ →[g]). Although there is only one occurrence of this replacement in the current data, it is suggested to occur as a developmental process for Arabic-speaking children according to the study conducted by Dyson and Amayreh (2000). Fricative stopping may also occur as an acceptable variant for some of the Arabic dialects (Ingham, 1971, 1994; Amayreh and Dyson, 2000; Ayyad, 2011). Therefore, based on different Arabic studies (i.e. Amayreh and Dyson, 2000; Dyson and Amayreh, 2007 and Ayyad, 2011), the results of this study are more logically explained as due to dialect factors rather than phonological processes.

From the control group data in the current study alveolar and postalveolar fricatives and emphatic fricative /sˤ/ tend to be dentalised which is consistent with what has been reported in several different Arabic studies (e.g. Dyson and Amayreh, 2000; Amayreh, 2003; Ayyad, 2011) and, for the alveolar and postalveolar fricatives, in English (Ingram *et al.*, 1985, Preisser *et al.*, 1988; James, 2001). As non-cleft dentalisation also occurs in children with cleft palate, the process is described in greater depth in the coming section.

There are two types of fronting; these are postalveolar fronting (i.e. /ʃ/→[s]) and velar fronting (i.e. /k,g/→[t,d]). Although fronting is a very common process across languages, e.g. English (e.g. Howard, 2007), Cantonese (e.g. So, 2007), and German (e.g. Fox, 2007), postalveolar fronting was the only type of fronting process observed in the current data and it was noted in only one child of the control group. The very limited occurrence of fronting processes is consistent with results reported in a study conducted by Dyson and Amayreh (2000), who reported that the process tends to disappear in Arabic-speaking children around the age of 3;5. A limited occurrence of fronting was not only reported in Arabic, but also in other languages such as Finnish (Kunnari and Savinainen-Makkonen, 2007) and French (Rose and Wauquier-Gravelines, 2007). The absence of any velar fronting and the limited occurrence of palato-alveolar in the current study and in the above-mentioned languages could constitute language-specific differences, as children tend to produce consonants which have high frequency of use more accurately than those with low frequency of occurrence (Edwards *et al.*, 2004; Munson *et al.*, 2005; Edwards *et al.*, 2011), although the lack of studies of sound frequencies in Arabic makes this difficult to judge.

Different findings have been noted in the Arabic literature on the acquisition of affricates by Arabic speakers. For instance, in Jordanian Arabic, Amayreh and Dyson (1998) reported that the affricate was acquired after the age of 6; 4, however the authors did not specify exactly the age of acquisition. Meanwhile Amayreh (2003), reports that the affricate is not acquired till around eight years old. In Kuwaiti Arabic (Ayyad, 2011), the consonant was acquired by 75% of the younger age group (i.e. four-year-old). In the control group of four- year-olds in the current study, de-affrication (i.e. affricate realised as a stop or fricative, /dʒ/ →[ð,d]), was found in the speech of two of four children. The inconsistent results found in the Arabic literature might be related to dialectal differences, for example, in Jordanian the affricate is usually not realised but rather replaced with fricative /ʒ/ as a dialectal variant. A further reason for the inconsistency could be due to the different definitions of de-affrication. For example, Amayreh (2003) uses the term 'de-affrication', defining it as a replacement of the affricate consonant with fricative. However, Ayyad (2011) does not use 'de-affrication' but rather uses the term 'stopping' to refer to the replacement of the affricate with a stop and the term 'fronting' to refer to the replacement of the affricate with a postalveolar fricative.

Some language-specific simplifications were demonstrated in the typically-developing children's speech such as de-pharyngealisation (de-emphasis), non-cleft pharyngeal backing and the lateral articulation of /r/. According to Dyson and Amayreh (2000), emphatics, particularly stops, are considered to be one of the most inaccurate places of articulation. Dyson and Amayreh suggested that this could be due to the articulatory complexity of emphatic consonants, their infrequent occurrence, and their low functional load. Due to the complex production of emphatics, children tend to simplify their production, using the process of de-pharyngealisation (i.e. loss of secondary articulation). In the current study, de-pharyngealisation occurred inconsistently for the emphatics /dˤ,sˤ/, while the other two emphatics /ðˤ, tˤ/ tended to be accurately produced. Thus, compared to the findings of

Dyson and Amayreh’s (2000) research, in the current study de-pharyngealisation was less common. Jordanian speakers and other Levantine dialects tend to replace some emphatics with other non-emphatic consonants and such replacements occur as acceptable variants. For example, /ðˤarf/ in MSA and Saudi Arabic tend to be produced as [zarf] in Jordanian Arabic, and /sˤaʁiːːr/ in MSA and Saudi Arabic tend to be produced as [zʁiːr] in Jordanian Arabic. This claim is based on a personal observation along with personal communication with native speakers of Jordanian Arabic and Syrian Arabic. The less common occurrence of de-pharyngealisation in the current study might be due to the high functional load of emphatic consonants in Saudi Arabic. In the light of the inconsistencies in reports to date, the development of emphatics across the Arabic-speaking world would be a valuable subject for future research.

It was suggested in Chapter 7 that non-cleft pharyngeal backing occurs as part of typical phonological development. This process has previously been reported in two studies; one is an unpublished study conducted by Makki[27] (1994) on Saudi children where target /χ/ was reportedly realised as [ħ] in the speech of some members of the control group as well as the group with cleft palate. The other was conducted in 2011 by Ayyad on Kuwaiti children, who found the process in four-year-old children (i.e. her younger age group). In the control group of the current study, the process was reported in the speech of two out of four children, who replaced the uvular fricatives with pharyngeal fricatives.

Typically-developing Arabic-speaking children generally have difficulty producing the alveolar trill /r/. According to different Arabic studies, children usually develop this consonant by the age of five to six years old (e.g. Amayreh, 2003; Ayyad, 2011). Investigations across languages have reported that the alveolar trill is considered to be one of the most difficult

[27] Makki (1994) did not report the name of the process; however it was noticed in her discussion about her control group.

consonants to produce, regardless of the language being used, such as Hindi (Srivastava, 1974); Igbo (Nwokah, 1986); Quiche (Pye *et al.*, 1987); Portuguese (Yavas and Lamprechrt, 1988); Italian (Bernthal and Bankson, 1988); Spanish (Carballo and Mendoza, 2000); Polish (Łobacz, 2000); Thai (Lorwatanapongsa and Maroonroge, 2007), and Arabic (Ayyad, 2011). In the current study, only one child (Child A) from the control group presented with difficulty in producing the trill; she consistently replaced the trill with the liquid [l] in all word positions. The substitution of /r/ with [l] (usually termed lateralisation of /r/) was reported in other Arabic studies such as those of Dyson and Amayreh (2000), Ammar and Morsi (2006), Khattab (2007) and Ayyad (2011). It was also reported in other languages such as Finnish (Savinainen-Makkonen and Kunnari, 2004) and Amharic (Mekonnen, 2008). It is interesting to find that only one child from the control group had a problem with producing /r/, however there is no direct answer for why the other three children from the control were producing the trill accurately. A future study is obviously needed to know whether substitution of the alveolar trill is a common process in typically-developing Saudi children or not.

10.2.1.1 Summary of phonological processes in typically-developing children

To sum up, the following processes were identified in the speech of the control group: stopping, postalveolar fronting, non-cleft dentalisation, de-pharyngealisation, non-cleft pharyngeal backing de-affrication, lateralisation of /r/, assimilation and final consonant deletion. Thus, apart from the absence of stopping of alveolar and postalveolar fricatives and the limited occurrence of fronting process, most of processes reported in the data of the control group aged 4:0 correspond to processes reported in previous findings for Arabic and other languages.

10.2.2 Non-cleft phonological processes in Arabic-speaking children with cleft palate

This section also addresses the following research question (Chapter 7):
What are the speech development patterns found in children with cleft palate in Arabic; and how do the results of this study relate to findings in other studies?

In this study, a number of developmental realisations not related to cleft palate were noted in the speech of children with cleft palate (See Table 7-20, Chapter 7). These include stopping, non-cleft dentalisation, de-pharyngealisation, de-affrication, affrication, non-cleft pharyngeal backing, fronting and gliding and/or lateralisation of /r/.

In the speech of children with cleft palate, stopping occurred as a replacement for voiced consonants including dental, alveolar, alveolar emphatic and uvular (i.e./ð, z, ðˤ, ʁ/). According to Jordanian studies, stopping tends to persist in typically developing children until the age of 2;0 ; after that age it is used only as a dialectal variant (Amayreh and Dyson, 2000). On the other hand, Ayyad (2011) reported the occurrence of stopping in older children up to five years old. As reported earlier in this chapter (section 10.2.1), stopping occurred only in one child of the control group and as suggested this process could be considered as an acceptable dialectal variant rather than a phonological process and this is concomitant with the finding reported above by Amayreh and Dyson (2000). (See section 7.8.1 for the results of the current study).

Some authors have suggested that a persistent stopping process might be a strategy adopted by children with cleft palate to avoid the imprecise production of fricatives (e.g. Russell, 1991; Harding, 1993; Hutters and Brøndsted, 1993; Harding and Grunwell, 1996, cited in Grunwell, 1998);

however, simplification of alveolar /z/ and emphatic alveolar /ðˤ/ is not surprising as these specific consonants are considered to occur late in Arabic speech development (Omar, 1973; Amayreh and Dyson, 2000). The late development of /z/ and /ðˤ/ implies the possible occurrence of some other kind of developmental processes too such as dentalisation of /z/ and de-pharyngealisation of /ðˤ/. Thus, the occurrence of the stopping process would be typical for their age. Also, some of the acceptable variants, on account of being sociophonetic/dialect variations, were in the form of stopping of dental and uvular fricatives, which is consistent with other Arabic studies (e.g. Dyson and Amayreh, 2000; Ayyad, 2011).

Although stopping of alveolar and post alveolar segments was present in the data of the cleft group but not the control group, results revealed that the occurrence of stopping in the cleft group is consistent with findings in other typically-developing Arabic studies reported above. However, as suggested earlier, the frequent occurrence of stopping in the cleft group could be related to their tendency of using the process as strategy to circumvent the imprecise production of fricatives.

As reported in the previous section, typically developing Arabic-speaking children as old as at least six years of age have difficulty producing the alveolar trill /r/. As evident from the speech of the cleft group in the current study, six children with cleft (i.e. out of 21) substituted the alveolar trill with one or more of the following consonants [ʁ, ɾ, rˠ, l, ʟ, w], all indicating either acceptable or normal phonological development. For example, substitution of /r/ with [l, ʟ, ʁ, rˠ, w] have been considered by Arabic studies as typical phonological development (Dyson and Amayreh, 2000; Ammar and Morsi, 2006; Ayyad, 2011). On the other hand, [ɾ] has been noted to occur as an acceptable dialectal variant (Amayreh and Dyson, 1998). Thus, the above mentioned realisations of / r/ are not related to cleft.

Again when comparing the findings of the cleft group with what was reported from the control group, it revealed that the former group tend to use a mixture of developmental replacements for the trill [l, ʟ, ʁ, $r^ɣ$, w], whereas the latter group used only [l] as a replacement for /r/. The different realisation occurring in the cleft group gives an indication of the intra-speaker variability usually found in the cleft population.

Among different phonological processes noted in the study, dentalisation is of particular note. According to the literature, dentalisation can either occur as a normal immaturity or as a consequence of cleft palate. As a cleft-related pattern, the feature has been noted in a number of studies. For example, in the Eurocleft study (1993) the feature was found in the subjects with cleft palate aged over eight years old. In another study (Hutters *et al*., 2001), dentalisation was reported in both cleft and control groups. Hutters and colleagues suggested that dentalisation could either be classified as a developmental feature or as a cleft speech characteristic. As a feature of typical phonological development, dentalisation has also been reported in a number of different Arabic studies (e.g. Dyson and Amayreh, 2000; Amayreh[28], 2003, Ayyad, 2011).For instance, Dyson and Amayreh (2000) and Ayyad (2011) noted that children tend to substitute alveolar fricative (grooved) with dental fricatives [θ,ð]. In Ayyad's study, the older age group (i.e. 5 years old) still had not acquired /s/, /z/ and /$s^ʕ$/ in all word positions; instead they were realised as slit dental fricatives across all word positions. In her 2011 study, Ayyad used different transcriptions to indicate different levels for the immature production of alveolar targets. Thus, /s/ is used when the target is completely grooved, [s̪] when alveolar fricative is slightly grooved, [$s^θ$] when the sound is slightly less grooved and [θ] when it is completely ungrooved .

Controversial findings have been reported in the literature as the process of dentalisation can occur in both cleft and non-cleft speakers. However, it is

[28] Amayreh did not use the term 'interdental articulation/dentalisation' in his studies, although the results showed the occurrence of this process.

suggested that non-cleft dentalisation might possibly occur because young children tend to have a smaller oral cavity before the eruption of the adult teeth (Ayyad, 2011) which affects lingual position for the production of alveolar and postalveolar sounds. On the other hand, dental realisation related to cleft might occur as a consequence of dental malocclusions related to cleft palate and thus affect the production of alveolar and postalveolar speech sounds (e.g. [s, z, ʃ, tʃ, dʒ]. In the current study, a distinction has been made between dentalisation that occurs as a typical developmental process (i.e. non-cleft dentalisation) which has been reported in both control and cleft groups and dentalisation related to structural anomalies associated with cleft palate (i.e. cleft dentalisation). As reported earlier, dentalisations of alveolar and postalveolar fricatives and emphatic fricative /sˤ/ have been reported in two children from the control group and this finding is consistent with findings reported in other Arabic studies reported above. The same finding was reported in the cleft group (see section 7.8.2, Chapter 7).

To discriminate between the two types, [θ]and [ð] symbols were used to refer to non-cleft dentalisation, whereas /s,z/→ [s̪, z̪] symbols were used to refer to misarticulations related to dental/occlusal abnormality (i.e. cleft dentalisation).

Additional processes noted in the cleft group other than the process reported in the control group, including: affrication and velar fronting. Although the occurrence of affrication in the cleft palate group was very limited but it is worth noting its occurrence in the current study as it is unexpected. An affrication process has not been classified or reported in the Arabic studies as a typical or disordered phonological process, except for Ayyad (2011) where she noted a limited occurrence of this process in the younger age group. In terms of other languages, affrication has been noted to occur in Cantonese as a feature of typical phonological development (So and Dodd, 1995). Furthermore, affrication (e.g. /s/ →[ts]) has been said to be normal stage in the development of alveolar fricatives in English, between the complete stopping stage (/s/→[t]) and realisation of /s/ as the target fricative

(Ingram, 1989). Thus, it could be suggested that the process of affrication of fricatives in Arabic might in some cases be considered a typical phonological process.

Despite the limited occurrence of the palato-alveolar fronting process and the absence of a velar fronting process in the control group, fronting of both palato-alveolar and/or velar consonants was reported frequently in the cleft group. The latter finding provides more support to previous studies (e.g. Peterson-Falzone, et *al*., 2001; Priester and Goorhuis-Brouwer, 2008) which suggest that children with cleft palate tend to display phonological processes which persist longer in relation to their non-cleft peers.

10.2.2.1 Summary of non-cleft phonological processes in Arabic-speaking children with cleft palate

In summary, the findings from this study suggest that children with cleft palate exhibit increasingly frequent and additional phonological processes compared to the control group - some of these processes are typical for their age and some are not. Thus, in addition to the processes found in the control group, children with cleft palate presented with affrication and velar fronting. These results lend support to findings in a number of previous studies (e.g. Chapman, 1993; Peterson-Falzone *et al*., 2001; Konst *et al*., 2003; Priester and Goorhuis-Brouwer, 2008) which contend that the structural constraint associated with cleft palate is the most significant factor affecting speech development and thus the phonological processes tend to persist for a long period when comparing them with non-cleft peers. However, there are also additional factors such as repeated hospitalisations and hearing difficulty related to middle ear effusion. Obviously all of the latter are associated with the cleft condition and may also contribute to the speech delays.

10.3 Cleft speech characteristics: cross-linguistic similarities and differences

This section addresses the following research question (Chapter 7):

What are the cleft speech features found in the speech of the Arabic children with cleft palate and how they are related to findings in other languages? Are there any patterns which have not previously been reported in the literature?

A number of previously identified cleft speech characteristics have been noted in the current study including cleft dentalisation, linguolabial lateral and palatal articulations, double articulation, backing, active nasal fricatives, velopharyngeal fricative, ejectives, weak/nasalised consonants, nasal realisation of plosives and fricatives and absent pressure consonants. While some of these cleft-related processes may be universal or at least extremely common cross-linguistically, other speech patterns found in this study may be language-specific. This section includes a description and discussion of the language-specific patterns as well as some of the interesting findings reported in the study. The structure of the following sections is organised according to the GOS.SP.ASS cleft speech characteristics (Sell *et al*., 1999).

10.3.1 Dental realisation related to cleft and linguolabial articulation

Misarticulations of sounds involving the tip/blade of the tongue have been reported in Chapter 7. Class III malocclusion usually affects the achievement of alveolar contact and thus results in dentalised articulation (Stengelhofen, 1993). This is because the maxillary space may be so limited that it prevents the normal-sized tongue from producing alveolar consonants precisely and as a consequence, the tongue contact may be advanced. The forward movement of the tongue *tip* contributes to the realisation of dentalised consonants, whereas the forward movement of the tongue *blade* contributes to the adoption of linguolabial articulation (see section 7.5.1).

10.3.2 Lateral and palatal articulation

Excessive posterior tongue contact may result in the air being directed either centrally or laterally, so that the anterior fricative targets /s,z,ʃ/ are realised as lateral [ɬ,ɮ] or palatal fricatives [ç,ʝ] (Gibbon and Hardcastle, 1989). In this study, lateral articulation of fricatives was reported in the speech of children with cleft palate (See Chapter 7). It is considered one of the most commonly reported features in individuals with cleft palate cross-linguistically (e.g. in Japanese: Yamashita *et al.*, 1992; in English: Harding and Grunwell, 1996; in Cantonese: Stokes and Whitehill, 1996; in Arabic: Shahin, 2006 and Al-Tamimi *et al*., 2011; in Amharic: Mekonnen, 2013).

Palatal articulation appears to be one of the least commonly occurring features in the current study although it occurs frequently in different languages (e.g. in English: Harding and Grunwell, 1996; in Cantonese: Stokes and Whitehill, 1996). It is interesting to note that the two children who used palatal articulation were also using the lateral articulation to produce the same target sounds in different contexts/elicitation modes which will be described later in section 10.8.

Factors contributing to the realisation of lateral or palatal articulation include hard palate abnormalities, e.g. fistulae, dental or occlusal abnormalities (e.g. Class III malocclusion), velopharyngeal incompetence, decreased sensation in the alveolar or palatal region and hearing loss (Gibbon and Hardcastle, 1989). It could be suggested that these different factors might have contributed to the realisation noted here.

Furthermore, a number of studies have reported a probable effect of cleft type on the realisation of palatal and lateral articulations (e.g. Michi *et al*., 1990; Yamashita *et al*., 1992) as they found that individuals with UCLP and BCLP tend to have more abnormal lingual movement than individuals with SPO. Thus, it is also worth considering the effect of cleft type on the realisation of lateral articulation and palatal articulation. Based on this, the current study revealed that from the eight children presenting with lateral articulation, five had UCP, three had BCP and there was no one with SPO (see section 10.7 below). The two children with palatal articulation also had UCP. These findings seem to support those of Michi *et al.* (1990) and Yamashita *et al. (*1992).

10.3.3 Double articulations

A number of studies (e.g. in English: Gibbon and Crampin, 2002; Howard, 2004, 2013; in Cantonese: Whitehill *et al*., 1995; in Swedish: Persson *et al*., 2006; in Amharic: Mekonnen, 2013) have found double articulations combining various different places of articulation (e.g. alveolar-velar, lingual-glottal, labial-lingual), although this does not appear to be true for all languages. For example, no published study could be found in the literature that reports double articulations in Japanese speakers with cleft palate.

As reported by Gibbon *et al*. (2007), the most common type of double articulation involves a glottal or pharyngeal restriction occurring concurrently with a closure at a higher level in the vocal tract e.g. a bilabial stricture or tongue-palate stricture in the oral cavity. In the current study, double articulation was only noted in two children (Nas and Sa) inconsistently, in the production of Arabic emphatics, /sˤ/ and /tˤ/. Nas realised /tˤ/ as [t͡q] and Sa realised /sˤ/as [ʔ͡q]. In these data, the only occurrence of double articulation as a replacement of emphatics is interesting; however, a possible explanation for this relates to the fact that Arabic emphatics are produced with a combination of primary and secondary articulations. The primary articulation involves an anterior tongue stricture, whereas secondary articulation involves retraction of the tongue body into the oropharynx (Bin-Muqbil, 2006).

Thus, in the case of the child who uses [t͡q], it is possible that Child Nas achieves the primary articulation [t] in [tˤ], but for the target secondary articulation the child overshoots the required tongue body retraction. The other noted double articulation in the current data, in which glottal constriction occurs simultaneously with a production at velar place of articulation (i.e. [ʔ͡q] for /sˤ/), occurred in the other child (Sa).

The observation of double articulations in only two children may relate to the difficulty in identifying such a process just by using perceptual analysis. Gibbon and Crampin (2002) conducted a study using EPG among 27 speakers with cleft palate. Using perceptual evaluation, the author found that none of the children had an abnormal production of bilabials; however when using EPG they found that three speakers with cleft palate were consistently replacing bilabials with double articulations.

Thus, there might be more occurrences of double articulations in the current study which the author has been unable to identify perceptually.

10.3.4 Backing

A common cleft-type pattern found in different studies is backing (e.g. Hardin-Jones and Jones, 2005; Shahin, 2006; Al-Tamimi *et al.*, 2011; Mekonnen, 2013). Backing is also known as retracted, backed-tongue placement or posterior placement of oral targets (Gibbon *et al.*, 2004). It affects sibilants, alveolar stops and uvular stops (Gibbon and Crampin, 2001).

Henningsson *et al*. (2009) have classified backing into two categories: backing within the oral cavity (palatal, velar or uvular place of articulation) and backing of oral targets to post-uvular place of articulation (pharyngeal or glottal place of articulation). With the exception of pharyngeal realisation of oral targets, all of the backed patterns of articulations, including palatal[29], velar and uvular realisations of alveolar and postalveolar target consonants, have been reported in the current study.

In this research, bilabial, dental, alveolar, postalveolar and emphatic targets were backed to velar and uvular places of articulation. Many studies have not included bilabials in the same category of backing, because they are labial not lingual articulations and as such are often less affected, or affected in different ways from tongue tip/blade consonants. However, the adoption of bilabial backing in this study was made based on Gibbon and Crampin's (2002) study where they reported at an early age for some speakers the occurrence of velar substitution for bilabial targets i.e. a backing process. This turned at later stages into the realisation of target bilabials as labial-velar double articulations.

Several hypotheses have been proposed by Whitehill and colleagues (2003) as explanations for the occurrence of the backing process. One of them is velopharyngeal incompetence, where the individual with cleft palate might be unconsciously trying to achieve valving at a point inferior to the velopharyngeal port prior to loss of pressure via the velopharyngeal port. Another possibility is the presence of oronasal fistulae, where the individual may be trying unconsciously to achieve a valve at a place posterior to the opening (i.e. fistula) to avoid air escape through the nasal cavity. Further possibilities have been suggested by Whitehill *et al*. (2003) including the occurrence of dental or occlusal abnormalities, decreased sensation of the alveolar region following palatal repair and hearing impairment.

Turning to backing to pharyngeal and glottal place of articulation, as reported earlier, these are considered to be one of the most commonly occurring features in speech related to cleft palate across several languages. However, and of significance for this study, pharyngeal consonants form part of the Arabic phonemic system, so one might reasonably predict that children would not use them as replacements of anterior target consonants, since that would risk phonetic neutralisation of Arabic phonemic

[29] In the current study, palatal has been described as one of the anterior oral CSCs (See section 7.5.1)

contrasts. As reported in previous chapters, many of the children used glottal replacements but, strikingly, none of the children used pharyngeal realisations as a substitution for dental and alveolar pressure consonants. That is, pharyngeals were mostly produced as accurate realisations of pharyngeal targets and occasionally used as replacements for uvular fricatives /χ/→[ħ], /ʁ/→[ʕ]. Since the uvular fricative /χ/ tends not to develop normally until the ages of 4;6 to 6;0 and the pharyngeal fricative[ħ] by the age of >4 (Amayreh and Dyson, 1998), it is not surprising that some of the children with cleft palate in this study used pharyngeal [ħ] to simplify the production of /χ/. As described above, the latter was not only reported in children with cleft palate but also in the control group and thus the process is considered as typical.

On the other hand, some of the children produced the target /ʕ/ at another place of articulation (i.e. /ʕ/→[ʔ]). A possible reason for this is that voiced pharyngeal /ʕ/ is one of the latest consonants to be acquired by Arabic children (>6;4) (Amayreh, 1998), whereas the glottal stop tends to be acquired early in the phonemic inventory of Arabic speakers, between the ages of 14 and 24 months in Amayreh and Dyson's (2000) study. Just one child (i.e. Child Ta) used a glottal fricative as a substitution for the voiceless pharyngeal /ħ/, although /ħ/ is usually acquired early (i.e. <2;0 to 3;10) (Amayreh, 1998). This could be due to the sociolinguistic influence of some East-Asian languages on the child's phonological development. In Saudi Arabia, many of the families recruit non-native Arabic-speaking babysitters and, as has been noticed, many children are spending significant amounts of time with a non-native speaker of Arabic who speaks Arabic in a different accent, with different phonetic realisations of target phonemes (author's personal observation). Thus, children who spend most of their time with the non-native Arabic speaker tend to have a phonetic distinctiveness as the result of sociolinguistic influences. The latter suggestion could explain child Ta's speech behaviour as his mother reported that he is, indeed, spending considerable amount of the time with a babysitter whose native language is not Arabic.

Pharyngeal fricative realisations for oral targets have not been reported in other cleft studies on non-European languages (i.e. Shahin, 2006; Al-Tamimi *et al*., 2011 in Arabic, and Mekonnen, 2013 in Amharic). What Shahin (2006) and Al-Tamimi *et al*. (2011) reported is the use of the pharyngeal stop (/ʡ/) as a substitution for emphatics /sˤ,tˤ/, which is, therefore, distinct in manner from the Arabic pharyngeal /ʕ/. Thus, no neutralisation results from use of the pharyngeal stop; nor does a disturbance occur in the phonemic system of Jordanian Arabic speakers. However, the pharyngeal stop in both of these studies occurred in only a small number of subjects so it is not a prevalent process. Mekonnen (2013) did not notice any of his Amharic-speaking participants using pharyngeal realisations. He suggested that this could be due to the effect of sociolinguistic factors of another language closely related to Amharic, Tigrinya, which, like Arabic, contains pharyngeal consonants (/ħ, ʕ/) that are considered to be one of the most important features that differentiate Tigrinya from Amharic. The Tigrinya language shares many similar vocabulary items with Amharics, but the Tigrinya accent has negative sociophonetic associations for Amharic speakers. Thus, Mekonnen suggested that the children in his study might be aware of the negative sociolinguistic connotations of pharyngeal variants and they might be avoiding the use of pharyngeals so they do not sound like Tigrinya speakers. This is different to Arabic where pharyngeals are part of the phonological system for all Arabic dialects, so that avoiding pharyngeals as compensatory sounds is more likely to have phonological reasons.

Since the glottal plosive and fricative are two of the consonants in the Arabic sound system, one might wonder why children in the current study and the other two Arabic studies (i.e. Shahin, 2006; Al-Tamimi *et al*., 2011) used glottal but not pharyngeal articulation as a posterior placement There is not a clear answer to this; however, using spectrographic analysis, Al-Tamimi *et al*. (2011) noted that children in their study in fact made covert contrasts, using creaky glottal [ʔ̰] rather than plain [ʔ] as the replacement for oral consonants. For example, in the word /ʔasˤ.far/ 'yellow', children in their study used a typically-produced glottal stop for target glottal stops, but for the word /tuf.faːħah/ 'apple' a creaky glottal stop was used to realise target /t/ (i.e. /t/→[ʔ̰]). By this strategy of covert contrast, it appears that the children are attempting to avoid neutralisation of phonemic contrasts. Al-Tamimi and colleagues did not report whether creaky production was a perceptible difference, i.e. whether listeners could detect it auditorily or not. However, in either case, it is possible that children in the current study use the same strategy to avoid phonemic neutralisation. This would be an interesting topic for future research using acoustic analysis.

10.3.5 Nasal fricatives and velopharyngeal fricative

Nasal fricative is the term used to describe nasal turbulence or nasal emission, normally when used to replace oral fricative consonants. The production of nasal fricatives involves stopping of airflow in the oral cavity and alternatively directing it into the nasal cavity (Harding and Grunwell, 1998). According to the original GOS.SP.ASS'98, nasal fricatives only occur in place of oral fricatives, rather than affricates and plosives (Sell *et al.*, 1999). However, Morley (1970, as cited in Peterson-Falzone *et al.*, 2001; Grunwell and Sell, 2001) suggested that nasal turbulence can also replace other sounds including plosives and affricates.

For some children in the current study, the pattern was, indeed, not exclusive to target fricatives but also reported for target affricate and plosive consonants (see velopharyngeal fricative in section 7.5.1.8). The same observation has also been noted in Farsi (Baranian, in press). The replacement of fricatives, affricate and plosives (i.e. pressure consonants) by nasal turbulence/emission is not surprising as pressure consonants tend to be affected in the presence of any structural inadequacy and/or reduced mobility of the soft palate. As suggested by Sell *et al.*, (1994), nasal fricatives are commonly associated with VPI and also might occur as a result of deviant learning. The same could be the reason for the presence of the velopharyngeal fricative. Thus the occurrence of nasal and/or velopharyngeal fricative appears to be universal in cleft speech.

10.3.6 Ejectives

Ejectives occur in only 20 per cent of world languages, including a number of American Indian and African languages (Ladefoged, 2005) and do not occur in Arabic. They are egressive non-pulmonic sounds which result from the compression of air in the pharyngeal cavity, specifically through the elevation of a closed glottis (Ladefoged and Maddieson, 1996). Ejective stops can be produced at different places of articulations, including bilabial, dental/alveolar, velar and uvular. Generally, bilabial ejectives are uncommon across languages when compared with other types of ejectives (Ladefoged and Maddieson, 1996; Maddieson, 2001). Ejective fricatives, e.g. alveolar fricative [s’] also occur in the world’s languages, although infrequently (Maddieson, 1984; Maddieson *et al.*, 2001), whereas ejective stops, specifically velar ejectives, are generally common across the 20 per cent of languages which have ejectives (Maddieson, 1984; Ladefoged, 2001; Best and McRoberts, 2003).

Ejective realisations for target pulmonic consonants in cleft speech have only been reported in a single study (Al-Awaji, 2008 in Arabic). Although Arabic does not have ejectives in its sound system, Al-Awaji (2008) reported consistent realisations of the alveolar trill /r/ as [k’] by one of the children with cleft palate, in word-final position. Interestingly, although the Amharic sound system contains both ejectives and pulmonic plosives at the same places of articulation, Mekonnen (2013) did not report the occurrence of ejectives as replacements for pulmonic consonants; instead ejectives themselves were replaced mostly by glottal plosives.

In the current study, bilabial [p’] and velar [k’] ejectives were noted as realisations of bilabial /b/ and postalveolar /dʒ/ pulmonic consonants, but only in word-final position. It is not immediately obvious why ejectives occurred in Arabic given that they have not been reported elsewhere in the literature. The realisation of ejectives in children with cleft palate gives an indication of how children are creative in terms of compensating for the structural challenges they encounter to produce the pulmonic sounds. However, the occurrence of ejectives in this study could be relevant as children with cleft palate tend to use other non-pulmonic airstreams. Thus, the participants in this study clearly seem to use a non-pulmonic airstream to manipulate air flow.

It is, however, also noteworthy that ejectives in the current study only occur in word-final position. Thus, it could be suggested that ejectives may not be the result of any structural abnormality but rather a strategy to emphasise the production of the sound, particularly considering the fact that the children in the study produced ejectives word finally. The latter has also been reported in normal speech by English speakers; for instance, Local (2003) suggested that this speech behaviour is common in word-final and utterance-final position in conversation.

10.3.7 Summary of cleft speech characteristics

In the present study, Arabic-speaking children with cleft palate presented with a range of speech features related to the structural defect. These include cleft dentalisation, linguolabial articulation, lateral/palatal articulations, double articulation, backing, glottal articulation, active nasal fricative, velopharyngeal fricatives, weak/nasalised consonants, nasal realisation of fricatives/plosives and absent pressure consonants. All of these features are reported in a number of cleft studies on other languages; however, a further language-specific pattern, ejectives, was also reported in this study and in another study conducted by Al-Awaji (2008).

As reported earlier, the speech patterns observed in the children with cleft palate in this study are mainly related to the structural abnormality affecting the airflow and the production of speech, and have been reported for other languages. However, a limited occurrence of some of the speech characteristics was noted (e.g. palatal articulation and double articulation). Furthermore, gliding of fricatives and affricates as well as backing to pharyngeal place of articulation were not noted in the present study, possibly for reasons related to the phonology of Arabic.

10.4 Voiced vs. voiceless

This section addresses the following research question (Chapter 8):
Overall, are voiced segments more affected than voiceless segments in children with cleft palate?

There are a number of studies in the literature indicating that children with cleft palate tend to develop voiceless before voiced consonants; thus /p t k/ occur before /b d g/ (Harding and Grunwell, 1998). This is assumed to be associated with a loss of sustained intraoral pressure related to velopharyngeal insufficiency which appears to be more problematic in voiced than voiceless consonants (Isshiki and Ringel, 1964; Malécot, 1968; Stevens, 1998; Harding and Howard, 2011). This is in contrast to typically developing children who usually develop voiced plosives /b d g/ earlier than their voiceless counterparts /p t k/ (Isshiki and Ringel, 1964; Harding and Grunwell, 1998).

Children in the current study achieved generally high percentages of voiced and voiceless segmental accuracy in both word-initial and word-medial positions. In contrast, word-final position showed a low percentage of accuracy in both voiced and voiceless consonants occurred in word-final position. It can be suggested that the low percentage of word-final consonants (both voiced and voiceless) reflects the tendency of children in the current study to delete the consonants word-finally.

Although the differences in accuracy between voiced and voiceless in initial and medial word positions only showed a very slight difference by position in the word (see sections [8.3.6.1]; [8.3.6.2]; [8.4.6.1]; [8.4.6.2]; [8.5.4.1];[8.5.4.2]), children generally showed a somewhat better ability in producing voiceless consonants than voiced consonants overall, across all word positions. This is in agreement with the suggestions made above by Isshiki and Ringel (1964), Malécot (1968), Stevens (1998) and Harding and Howard (2011). The most affected voiced consonants in all word positions are /ð, ðˤ, z, ʁ / where the children could not maintain the vocal fold vibration and thus voiced consonants were replaced by voiceless consonants. Given that the differences in accuracy between voiced and voiceless in initial and medial word positions showed a very slight difference by position in the word, results of the current study suggested a partial support to the hypothesis in the research question where voiced segments are more affected than voiceless segments.

10.5 Comparisons of most and least accurately produced consonants

This section addresses the following research question (Chapter 8):

Which are the most and least accurately produced consonants in cleft speech in Arabic-speaking children, and how do the results of the current study relate to previous findings?

Across all different word positions, the most accurately produced segments were the post-uvular sounds (i.e. pharyngeals and glottals), most likely because the places of articulation of these sounds are beyond the structural defect caused by the cleft palate. On the other hand, alveolar and postalveolar fricatives, as well as the fricative emphatic /sˤ/, were generally the least accurately produced segments, which is in common with previous studies (e.g., Spriestersbach *et al.*, 1956; Subtelny, 1959; Morley, 1970; Van Demark, 1979; Albery, 1991; Harding and Grunwell, 1993; Brøndsted, *et al.*, 1994; Al-Tamimi *et al.*, 2011). In other words, sibilant fricatives tended to be distorted more than non-sibilants. Typical speakers tend to produce alveolar fricatives by combining the upward movement of the tongue tip or blade and the lateral margins of the tongue with the alveolar ridge, creating a groove down the tongue centre (Howard, 1995). Due to the structural abnormality related to cleft palate (e.g. hard palate, dental malocclusion), it can be suggested that such precise movement is challenging for speakers with cleft palate and thus has an impact on the normal production of alveolar fricatives (i.e. sibilants). Furthermore, many speakers with a cleft palate have a restricted anterior tongue position caused by the structural defect (e.g. typically a class III malocclusion) (Harding and Grunwell, 1996), and thus it is suggested that the available space for the tongue is limited for the production of alveolar and postalveolar consonants.

10.6 Comparisons of most and least accurately produced manner /place of articulation

This section addresses the following research question (Chapter 8):
What are the most and least affected manners/places of articulations and how are these related to findings of previous studies?

Due to the effect of the structural abnormality, some children use an active strategy to avoid hypernasality or nasal emission by changing the place and/or manner of articulation, particularly for the production of obstruents (Chapman and Willadsen, 2011). Chapter 8 of this study investigated the question of the most and least affected manner and place of articulation in Arabic-speaking children with cleft palate: here the results are discussed in comparison with studies of other languages.

As predicted from the literature, plosives, fricatives and affricates (the obstruent consonants) were the most affected manners of articulations across all word positions. This is due to the fact that obstruents, which require high intraoral pressure, are considered to be difficult for children with cleft palate to produce since they are vulnerable to weakening or nasalisation due to

VPD (Watson *et al*., 2001; Peterson-Falzone *et al*., 2006). As a result, manner of articulation in some speakers with cleft palate is preserved while sacrificing the place of articulation and this is called compensatory articulation.

As reported in Chapter 8, consonants with a postalveolar place of articulation together with emphatics were the most affected segments. As noted from the speech data of children with cleft palate, the single postalveolar fricative target tends to be either lateralised, fronted to alveolar place of articulation and thus realised as [s], or dentalised (see sections 7.5.1.1 and 7.5.1.3 in Chapter 7). Thus, in Arabic, /ʃ/ is more vulnerable than /s/ and this is in agreement with Locke's (1983) suggestion in that, in terms of articulation, the alveolar fricative /s/ is universally easier to produce than the postalveolar fricative /ʃ/. In children acquiring English, for example, postalveolar fricatives tend to be replaced with alveolars (Weiner, 1979). These findings for English are not in agreement with results reported for other languages including Japanese and Amharic, where /s,z/ are commonly realised as [ʃ]; which suggests that /ʃ/ is easier to be produced than /s/ (Nakanishi *et al.*, 1972; Beckman *et al.*, 2003; Li *et al.*, 2009, 2011; Mekonnen, 2008, 2013).

However, the different findings reported from the above studies and the language-specific differences could also be related to the frequency or usage of a specific sound in a given language; hence it appears that children tend to produce sounds which have high frequency of use more accurately than sounds with low frequency of use (Edwards *et al.*, 2004, 2011; Munson *et al.*, 2005). Thus, it can be concluded that the affected manners of articulation support the findings in other cleft studies reported above. In terms of places of articulation, the findings of the current study revealed that the affected places of articulation tend to be related to the frequency of use of a sound/place of articulation in a specific language compared to another.

10.7 Accurate segmental production in relation to age at assessment /at repair and cleft type

This section addresses the following research question (Chapter 8):

How are age of participants, age at repair and cleft type related to their speech production and how is this related to findings of previous studies?

In Chapter 8, this study explored whether either age at assessment or age at cleft repair was related to the cleft children's accuracy in the production of consonant segments. The results indicated no correlation between accuracy of consonant production across all word positions and age at assessment. This is in contrast with previous studies reviewed by Lohmander *et al.* (2011) where she reported an association between age and accurate segments; that is, as age increases, fewer speech problems occur that require speech therapy.

Similarly, no correlation was observed between age at repair and accuracy of consonant production. This is in contrast with previous research studies reporting that accurate realisation of segments increases as the age at repair decreases (Hardin-Jones and Jones, 2005; Chapman *et al.*, 2008). One cannot exclude the possibility that language differences might be a reason for the differences in results noted between the mentioned studies and the outcomes found in the current study. However, again a firm conclusion cannot be reached. In general, the absence of a correlation in the present study might be explained by the relatively small sample size, which affects the statistical power or by the fact that all of the children in the current study had relatively early repair. Furthermore, the design of the current study is not longitudinal and thus a conclusion cannot be drawn on the relationship between age at assessment/age at cleft repair and accuracy of consonant production (e.g. Hutters and Brøndsted, 2001; Lohmander *et al.*, 2011).

Concerning speech production as a function of cleft type, the results revealed that, in general, children with SPO (i.e. cleft of the soft palate only) cleft-type have more accurately produced segments than other types of cleft (i.e. UCP and BCP). This finding is consistent with previous studies (e.g. Van Demark and Hardin, 1985; Albery and Grunwell, 1993; Karling *et al*., 1993; Hardin-Jones and Jones, 2005). For example, Hardin-Jones and Jones (2005) suggested that children with SPO presented with limited need for the help of speech therapists, which indicates that fewer sound errors present with this cleft type, whereas the need for speech therapy increases as severity of the cleft increases. The latter suggestion is also consistent with the findings in the current study as children with BCP (with/without CL) have the least accurately produced segments. Overall, the cleft type results suggest that cleft type is a more important factor than cross-linguistic effects determining severity of outcome.

10.8 Variability and individual differences and their clinical implications

This section addresses the following research question (Chapter 9):
Is there any significant inter- or intra-speaker phonetic and phonological variability observable in the data and if so, is it conditioned by word position and/or elicitation mode?

Throughout the data, intra- and inter-speaker variability has been noted in the speech production of the children with a cleft palate. However, this is not unusual as such variability has often been noted in the literature (e.g. Kuehn and Moller, 2000; Klintö *et al*., 2011; Howard, 2013). Intra-speaker variability was noted in the data in terms of atypical segmental productions which differed, sometimes, according to word position and/or elicitation mode (i.e. spontaneous or repetition). Given that all of the children in this study are between four and seven years old, and all had a history of cleft palate, it can be anticipated that intra-speaker variability presented for at least three reasons. First, variability is known to occur as a part of typical phonological development (McLeod and Hewett, 2008) where phonological processes gradually decrease, indicating positive phonological developments. Secondly, variability could be a sign of phonological impairment where significant percentage of words is produced incorrectly within the same linguistic context (Dodd, 1995; Holm *et al*., 2007). Thirdly, it could occur as a result of cleft (Harding and Grunwell, 1996).

Inter-speaker variability has also been reported in the current study. That is, children do not differ only in terms of use of non-cleft versus cleft patterns, but also the cleft speech characteristics (CSCs) they use vary between different speakers. Differences between the speakers provide a picture of creativity in children in terms of responding to the articulatory and perceptual constrains related to the cleft palate (Broen *et al*., 1993; Howard, 1993; Harding and Howard, 2011). Also the inter-speaker variability could occur due to different influencing factors associated with cleft palate such as recurrent hospitalisation, or hearing problems associated with middle ear effusion.

It is important for the speech therapist to identify variability in children's speech production, and to determine the root cause or causes of the problem (e.g. VPI, class III malocclusion, fistula, hearing difficulty). This helps in achieving an accurate differential diagnosis of an individual's speech disorder and thus determining the ideal form and content of a treatment regime (Shriberg, 2003).

To illustrate and exemplify inter- and intra-speaker variability, four children with cleft palate were chosen - Nasreen, Saud, Shoog and Saad (Chapter 9). It is interesting to note that each single study showed the wide variation in each speaker's profile. The variability appears to result from a combination of the children's attempts to solve the problem caused by the structural abnormality related to cleft palate together with phonological processes which occur as a normal phonological development. Thus, for the problems related to cleft palate, some of the children adopted the process of glottal articulation, whereas others realised the consonants nasally. On the other hand, some children used a backing process together with another process such as the use of nasal fricatives.

Saud's speech profile, for example, is one of the interesting illustrations of inter- and intra-speaker variability occurring in children with cleft palate. Thus, along with the realisation of different patterns, including pervasive occurrence of nasal realisations and glottal stop, he also used unusual emphatic replacements for the trill (i.e. /r/→[dˤ ,tˤ] and at other times replaced the trill with nasals (See Table 9-6). A further interesting example of variability in the current study was noted in the form of different contextually-motivated realisations when single word and connected speech production were compared. Thus, consonant productions in sentence repetition were less accurate and more variable than the single word productions. This is similar to the observations reporting that children with non-cleft atypical speech production exhibit more atypical connected speech production than in single words (Grunwell, 1987; Hodson and Paden, 1991; Stackhouse, 1997; Howard, 2004, 2007, 2013).

The occurrence of difficulty in sentence repetition task can be anticipated; since sentence repetition task is a controlled context. Therefore it is unnatural, requiring precise recall of sentences that may contain unfamiliar vocabulary and grammatical structures and thus not permitting lexical selection and avoidance (Speake *et al.*, 2011). Phonetic variability was also evident across different word contexts. Some of these variations were consistent while others were unexpected.

As found in studies of other languages, all of the Arabic-speaking children with cleft palate in the present study presented with typical developmental phonological processes as well as cleft speech characteristics; thus, when designing an intervention plan, it is essential to report such kinds of typical phonological development and to compare them, if present, with the atypical speech patterns related to cleft palate and other developmental speech difficulties (Grunwell, 1982; Miccio and Scarpino, 2008).

10.9 Clinical implications

This section addresses the following research question (Chapters 7, 8, 9):
What are the clinical implications of the identified speech production features?

The study contributes to the literature by providing information about cleft speech characteristics in Arabic, a language that differs significantly from previously reported languages in the cleft literature in terms of having emphatics, pharyngeals and glottals as part of the sound system. Speech characteristics of Arabic-speaking children with cleft palate, to date, have only been reported in a very limited number of studies with small participant numbers (i.e. Makki, 1994; Shahin, 2006; Al-Awaji, 2008; Al-Tamimi *et al*., 2011).

This study reveals many similarities between cleft speech in Arabic and other languages: dental realisation related to cleft palate, lateral articulation, palatal articulation ,double articulation, backing to velar and uvular ,glottal articulation, active nasal fricatives, velopharyngeal fricative, weak/nasalised consonants and nasal realisation of plosives and fricatives. Furthermore, the study also reveals some differences (i.e. pharyngeal articulation, gliding of fricatives and affricates) as well as additional patterns (i.e. ejectives, strong articulation) which have not been reported in other languages. The clinical implications of these findings are now discussed.

Individuals with a history of cleft palate may present with abnormal speech production and resonance related to the structural abnormality, even after surgical intervention. Whenever speech-related problems occur, it is important for the speech therapist to assess the child’s speech productions, identifying atypical patterns and, if possible, making a distinction between active and passive (i.e. obligatory) processes. Thus, analysing speech production is important for the sake of developing an intervention plan and evaluating the potential effect of surgical versus speech intervention. As reported earlier, passive processes occur as a consequence of structural abnormality (e.g. VPI or malocclusion) that leads to problems affecting resonance (i.e. in the case of VPI, palatal fistula, blockage in the nasal cavity) or the production of obstruents (e.g. in the case of palatal fistula, malocclusion, etc.). The passive speech production features recorded in this study included nasalised and weak consonants, nasal realisation of fricatives and/or affricates, nasal realisation of plosives and absent pressure consonants. For this type of process, speech therapy is often ineffective as the place of articulation is usually intact, so the best recommendation is medical or surgical intervention (Nagarajan *et al*., 2009; Sweeney, 2011), after which speech therapy could be initiated if still needed.

In terms of active processes, children compensate for the structural abnormality by changing the articulatory placement. For instance, if there is VPI, some children adapt to the problem by changing the place of articulation of oral consonants. Thus, oral consonants tend to be produced more posteriorly (e.g. glottal articulation, pharyngeal articulation). Not only VPI but also malocclusion can lead some children to develop a compensatory strategy by using, for example, lateralisation. A number of misarticulations have been identified in the current study which occur as a consequence of an active cleft strategy to compensate for the structural abnormality, including cleft dentalisation, linguolabial articulation, lateral articulation, palatal articulation, double articulation, backing, glottal articulation, active nasal fricatives and velopharyngeal fricative. Active processes (i.e. compensatory articulations) usually require speech therapy to correct the place of articulation (Kummer, 2011).

In common with studies in other languages, glottal articulation was one of the most frequently occurring compensatory articulations in this study. The use of glottal articulation as a compensatory articulation has been considered by many authors as one of the most challenging misarticulations to address (e.g., Kuehn and Moller, 2000; Peterson-Falzone, *et al*., 2001; Scherer, *et al*., 2008), particularly if this behaviour becomes established in the child's phonetic and phonological repertoire, thus reflecting the importance of early speech evaluation and intervention.

Concerning speech therapy for the active processes, there are a number of ways in which phonological and articulatory approaches can be combined to address children's speech output processes. For children who exhibit a glottal realisation pattern for target oral phonemes (e.g. Child Nasreen), it will be important to select an appropriate intervention approach so that glottal realisations could be destabilised in the child's speech without compromising production of the glottal phoneme that is part of the Arabic sound system. This could be achieved by choosing, for example, a multiple opposition intervention approach (Williams, 2000), which is similar to a minimal pairs approach but rather focuses on several target sounds simultaneously as a group. Thus it is suitable for children who have limited sound inventories across all word positions (Williams, 2010). Taking Child Nasreen as an example, she use glottal [ʔ] as a substitution for several segments, /b, f, ð, θ, t,k /, thus many places of articulation are affected. In this case, place of articulations could be contrasted using a visual component; for example, demonstrating to the child that some of these targets require visible labial or lingual movements in the front of the oral cavity, /b, f, ð, θ, t/, which the child has been producing as a glottal stop require more frontal posturing. Thus, visual characteristics of the sound classes may be emphasised to the child. Manner of articulation could also be addressed in the therapy through working on the differences between plosives and fricatives.

When setting an intervention plan, it is also essential for the therapist to identify the most affected sound classes. For the Arabic-speaking children in the current study, they encountered most difficulty in producing the emphatic /**sˤ**/, alveolar and post alveolar fricatives (/z,s,ʃ/) respectively. Although the problems with the latter sound classes could have been predicted from the literature, the difficulties associated with emphatics are variable in the current study. Hence, children demonstrated phonetic variability across different word/syllable structures. Most of the children showed the ability to produce emphatics accurately; however, this was not consistent: they sometimes simplify the production of emphatics by using de-pharyngealisation or dentalisation - processes that are considered typical in phonological development. In fact, emphatics are categorised as one of the latest consonants to develop (i.e. 6;4) (Amayreh, 2003) and are usually depharyngealised in normal phonological development in Arabic (Ayyad, 2011). In contrast to substitution related to typical phonological development, other replacements occur as a consequence of structural abnormalities related to cleft palate. These include backing, glottal articulation, double articulation, weak articulation/nasalised, nasal replacements, nasal turbulence/emission and nasal fricative. When planning intervention, it is therefore important to determine the root cause of the replacement, whether it is associated with a typical phonological development process, phonological difficulty or specifically related to the cleft (Harding and Grunwell, 1996; Harding and Howard, 2011). As children in the current study are aged between four and seven years old, it is acceptable at their age to use the simplification processes of de-pharyngealisation and dentalisation.

It is also important in therapy to work on sound classes rather than individual consonantal segments, bearing in mind the frequency of occurrence of the sound in the words of the language examined and the age of phonological development for that consonant in the examined language. Although most of the children in this study had an early palatal repair (mean = 15.2 months), some of them are still encountering speech difficulties related to cleft palate between the ages of four and seven. As suggested earlier in this section, these children would benefit more from the early palatal repair if they regularly attended speech therapy sessions (Smith and Guyette, 2004; Persson *et al*., 2006). However, most of these children are living at a significant distance away from the capital of Saudi Arabia, Riyadh, which is where a number of hospitals that provide care for cleft patients are situated, or from other cities that provide services and care for children with cleft palate; thus it is difficult for most of the children and their families to access speech therapy services on a regular basis. Added to this, there is still a shortage of professionals (including speech therapists), working in cleft care, particularly in the small cities and rural regions.

A further implication of the different speech production features found in this study is that even though many of the cleft-speech characteristics identified in the Arabic data are considered to be universal across languages (e.g. Brøndsted *et al*., 1994, Henningsson and Willadsen, 2011), there appear to be language-specific features related to the phonetic and phonological system of Arabic. It is already known that high-pressure consonants are vulnerable speech sounds for children with cleft palate and that the number of these consonants differs from one language to another. As discussed in the literature review, English, for example, has 16 pressure consonants in comparison with only two pressure sounds in the Hawaiian language (Hutters and Henningsson, 2004). Therefore, it could be predicted that due to different phonetic inventories, English language speakers with a cleft palate will demonstrate more compensatory errors than speakers using the Hawaiian language. Similar findings to English might also be speculated for Arabic speakers as the latter have the same number of pressure consonants in addition to different places of articulation (i.e. uvulars, pharyngeals and glottals) and manner of articulation (i.e. emphatics). The existence of emphatics in Arabic may pose extra challenges for speakers with cleft palate as emphatics have two places of articulation and thus may require a high degree of articulatory competence in producing them. Moreover, the number of different vulnerable sounds across languages is, in fact, not the only factor that affects speech for individuals with cleft palate; the frequency of their occurrence also plays a major role in a given language (Henningsson and Willadsen, 2011). Thus, determining the frequency of occurrence of sounds is important as a language could have a large phonetic inventory of vulnerable sounds but their occurrence might be very limited in words or contexts. Limited studies are currently available on the frequency of occurrence of consonants in Arabic and further studies would be welcomed.

The differences between languages in terms of their phonetic characteristics and the number of vulnerable consonants might make one language more difficult than the other. Lohmander and Olsson, 2004 recommended to take these language-specific phonetic characteristics out of the equation. Thus, speech sounds which are shared between the languages are identified and phonetic inventories across languages are compared (Lohmander and Olsson, 2004). However, while this approach is useful for cross-linguistic comparison, it has limitations in terms of ignoring important speech units for an individual language and thus the way speakers employ different strategies to deal with the speech production difficulties posed by a particular language would be also missing.

In addition to speech difficulties reported as a consequence of structural abnormality related to cleft palate, children in this study presented with speech difficulties related to typical phonological development. Therefore, in clinical practice it is important to identify the root of the problem with reference to the typical developmental patterns based on the child's age and to deal with it accordingly. Taking emphatics as an example, many of the children in the current study failed to realise the pharyngeal component of target emphatics; however because emphatics are one of the late consonants to develop in Arabic (age 6; 4), no intervention needs to be conducted for the children in this study at this stage.

With the combination of different factors affecting the speech of children with cleft palate, it is important to raise the awareness of the family about how important it is for their children to attend speech therapy sessions regularly and to avoid any disappointment, they need to be aware that the progress of speech will be changed gradually rather than dramatically after the palatal repair. It is also important for the family to recognise the importance of home-based practice, and the role of the therapist is important to ensure the parents' participation in intervention activities at home. In relation to this, there might also be significant cultural/international differences affecting parents' attitudes towards and expectations of speech therapy (Sell *et al*., 2011).

10.10 Limitations

One of the main aims of the study was to develop the Saudi Arabian GOS.SP.ASS. While conducting the study, several limitations emerged. The following section describes these methodological issues related to the design of the elicitation materials and then points out various limitations of this study in general.

10.10.1 Methodological issues

As reported earlier, there were many challenges related to the lack of appropriate assessment material in Arabic. Although other single word assessments exist (Amayreh and Dyson, 1998; Dyson and Amayreh, 2000; Ayyad, 2011), none of them were suitable to capture sound segment use in the Saudi Arabian dialect. Picture naming was used to elicit single words spontaneously; as suggested by Sell *et al*. (1999) certain points were considered while constructing the single words, including the following:

The pictures:

1. Need to be familiar to the child's environment. For example, wild animals (e.g. squirrels, zebras, pigs) would not be accurate for testing the Saudi child.
2. Need to be imageable. This is important as imageable words are better for eliciting words from speakers than abstract words (Givon and Friedmann, 2013).
3. Should not have several possible synonyms. For example, in Arabic, the word /ʃʊb.baːk/ 'window' has various acceptable synonyms including [tˤaːgah], [dɛriːʃah], and [naːfiðah]. So, if the word that has been selected to elicit the target segment is /ʃ/ and the child uses one of the synonyms, the target segment cannot be examined.

Attempts were made to meet all of the three points mentioned above and their applicability was tested in a pilot on five typically-developing children (aged 3;0 and 4; 0). Revisions for the tested words were then undertaken based on the observations on the productions found in the pilot study.

Even following these modifications, however, limitations were still discovered at later stages. For example, although the target word /tʊf.fæħah/ 'apple' is familiar to the child's environment, imageable and does not have a synonym, the word includes two consecutive consonants at the first syllable boundary /tʊf.fæħah/. As noted from the findings, this is not recommended particularly when testing a child with cleft palate as the two consecutive consonants /f.f/ will probably both be affected, especially when the child has nasal turbulence or nasal emission. The same applies for other target words (e.g. /dʊk.toːrah/); notice that if the target segment in the latter word (i.e. /dʊk.toːrah/) is /t/ and the child is suffering from nasal turbulence, both /t/ and the adjacent /k/ would be affected. Thus, Sell and colleagues (1999) recommended choosing words that do not have two consecutive consonants. In other words, any two consonants should be separated with a vowel (e.g. /dʒʊbʊn/). However, the latter suggestion cannot be easily achieved for all of the words in Arabic and proved particularly challenging, given the structure of words in Arabic, phonotactic features and grammatical considerations.

Thus, further work is now planned to revise the list of single words used in the picture-naming task and re-test its suitability on children with cleft palate as well as typically-developing children. This is important in order to produce the most effective set of words for children acquiring Arabic.

For the construction of sentences, Sell and her colleagues (1999) suggested some guidelines for consideration. Attempts were made to follow the suggested guidelines; however, once again a number of challenges occurred which related particularly to the phonological constraints of Arabic. For example, some sounds do not occur frequently especially in word-final position, notably /ð^{ʕ}, ð/. Dialectal variation is another challenge where the production differs for some of the consonants according to the regional accent or dialect of the speaker, e.g. /θ / →/s/, /d^{ʕ}/→/ð^{ʕ}/, /q/→/g/. Furthermore, one of the guidelines is to include only the target sound where possible with the remaining sounds in the sentence consisting of only vowels and approximants (e.g. in English: Bob is a baby boy). An attempt was made to follow this guideline but due to the phonotactic features and grammatical considerations of Arabic, the problem could not always be avoided.

10.10.2 Other limitations

Although the sample size of the current study is considerably larger than those of Shahin's (2006) and Al-Tamimi's *et al*. (2011) studies, it would be, nevertheless, useful to have a larger sample with a larger number of particpants in each group (e.g. 10 participants with BCP and 10 participants with UCP). This would make it similar to, for example, Persson *et al*., 2006). Alternatively a study could recruit the same number of participants as used in this study (21 participants) but all with same type of cleft (e.g. 21 participants with BCP), making it comparable with other studies, e.g. Chapman, 2011; Lohmander, *et al*. 2011. Hence, as noted in Chapter 8, because the 21 participants had different types of clef this made it difficult to be confident about the statistical analysis of the relationship between accurate segmental production and the two variables, 'age at assessment' and 'age at repair'.

Furthermore, the unavailability of published studies on speech development in Saudi-Arabic-speaking typically-developing children made it difficult to interpret some of the findings, such as non-cleft pharyngeal backing. Moreover, information such as type of surgery, presence or absence of fistula, timing of speech intervention, dental and occlusion status was not always available, although such information would help in considering some of the findings reported in this study. For instance, information on the timing and amount of speech therapy received by individual children would help in explaining the relationships between segmental accuracy and age at assessment in the groups in the study. Moreover, as noted in Chapter 8, the fact that the number of children in each cleft group was not equal made it difficult to apply statistical analysis for comparing the speech productions based on the cleft type.

There are also some limitations in terms of the methods used in the study. As discussed in Chapter 4, perceptual analysis using transcription has a number of limitations particularly in terms of inter-rater reliability (Sell, 2005). However, perceptual analysis has been strongly recommended as the "gold standard" for the analysis of cleft speech (Sell, 2005) and in the current study, the second transcriber had specialist training in the transcription of cleft speech in preparation for the reliability exercise.

For the reliability assessment, although the results of transcription agreement have met the basic standard set in the literature, the level of agreement still needs to be improved (see section 6.5.2, Chapter 6). The level of agreement achieved on transcription of atypical speech in the current study is expected since broad phonetic transcription is more reliable than narrow (Shriberg and Lof 1991; Brøndsted *et al.*, 1994). Another well-known issue associated with transcription is that it is often said to be subjective and unreliable (Shriberg and Lof 1991; Howard, 2011). However, for resonance and airflow agreements, the two transcribers agreed completely for the entire set of items, including hypernasality, hyponasality, nasal emission and nasal turbulence.

10.11 Suggestions for future studies

The results of the current study and its limitations offer the following insights and suggestions for future studies:

- Further studies on Arabic employing a longitudinal design are warranted to examine the role of early surgical and speech intervention in the speech production of children with cleft palate.
- Longitudinal design is also warranted to study speech development in typically developing Saudi Arabic-speaking children, where there is still very limited information for the purposes of clinical comparison.
- A further study of the specifics of glottals and pharyngeals is needed in Arabic cleft speech, and instrumental and/or acoustic studies would help to investigate the presence of covert contrasts. Information from electropalatography (EPG), for example, in the Arabic language is likely to provide very useful information, where the EPG patterns and findings of normal speech, speech disorders in general and cleft palate speech in particular, could be different in Arabic-speaking individuals because of the occurrence of sounds specific to Arabic (i.e. alveolar trill and emphatic sounds). Furthermore, the use of EPG would help to clear up the limited occurrence of double articulations in the current study (see section 7.5.1.5 and 10.3.3) and in identifying issues surrounding other potential covert contrasts (e.g. lateralised articulation). EPG can also provide information on the compensatory articulations and lingual behaviours of emphatics encountered by individuals with cleft palate.
- Studies using larger sample sizes need to be carried out in order to investigate the relationship between speech output and significant variables such as age at assessment, age at repair and cleft type in Arabic-speaking children with a cleft palate.
- As some of the speech processes encountered in this study could occur either as a feature of typical phonological development, in relation to cleft palate or as a consequence of hearing impairment, (e.g. dentalisation, lateralisation and palatalisation, Eurocleft study,

1993; Nelfelt, 1999; Hutters *et al*., 2001), differential diagnosis should be applied in a research study to identify the root cause of the different speech problems encountered. This could be done by conducting an oral motor examination and reviewing the patient's medical notes in combination with phonetic and phonological analysis; and thus the origin of the cause could be determined accordingly.

The current study has expanded our knowledge about speech production in relation to cleft palate in the Saudi Arabic-speaking children. There are many issues arising from the study, and discussed in this section, which should be addressed in the future. Further, the limitations discussed above will help in shaping and refining future research to improve our understanding of phonetic and phonological development in Arabic-speaking children with and without cleft palate in Saudi Arabia.

10.12 Conclusion

One of the aims of this research was to describe the speech features of Arabic-speaking children with repaired cleft palate, by developing and using a modified version of the GOS.SP.ASS (Sell *et al*., 1999). Unsurprisingly, given the previous literature, it was found that cleft palate with or without cleft lip has an adverse effect on Arabic-speaking children's articulation and resonance. These effects have been described and discussed in the results and discussion chapter. The cleft speech characteristics observed in this study have also been considered in relation to speech characteristics reported in other languages.

One of the contributions of the current study is that it provides a detailed description of speech characteristics of Saudi children with cleft palate. It also examined cross-linguistic similarities and differences in relation to various theoretical issues such as universal vs. language-specific aspects of cleft-related speech. The results of this study indicate that the speech characteristics of Saudi children with cleft palate are not entirely consistent with previous cross-linguistic studies of cleft palate speech, as a previously unreported speech production feature emerged in the data *ejectives* - which suggests that not all characteristics of cleft palate speech are universal. Rather, some speech features emerge in response to the particular structural and systemic properties of a specific language; in this case, Saudi Arabic. Furthermore, some of the frequently observed features in other cleft studies have not been reported in the current study e.g. gliding of fricatives and affricates, and pharyngeal realisations. Particularly with respect to the lack of pharyngeal substitutions, the study suggests that the specific characteristics of the Arabic phonological system have influenced the compensatory strategies adopted and avoided by the children. It is suggested that because pharyngeal consonants, form part of the Arabic phonemic system, so children in the current study did not use pharyngeal place of articulation in compensatory realisations of anterior target consonants, since that would risk phonetic neutralisation of Arabic phonemic contrasts.

A further research theme of the current study considered speech production in relation to age at assessment/surgery and/or cleft type. In terms of the association between the age at assessment/age at repair and segmental accuracy, the study shows non-significant correlations. However, a firm conclusion for the correlation between accurate segmental production and age at assessment/repair could not be drawn, due to the small sample size which affects the statistical power.

In terms of cleft type in relation to speech production, children with clefts of the soft palate only have more accurate production of consonants than children with either unilateral or bilateral cleft palate, and (once again) this result is in agreement with findings in previous reported studies (e.g. Michi *et al*., 1990; Yamashita *et al*., 1992).

The most important contribution of the current study may prove to be the development of the Saudi Arabian version of GOS.SP.ASS, which was based on the GOS.SP.ASS (Great Ormond Street Speech Assessment: Sell *et al*., 1999). The Saudi Arabian GOS.SP.ASS involves a list of single words as well as sentences which were designed specifically for Saudi speakers and thus made an important contribution to the study of the cleft speech in Saudi Arabia.

Including both elicitation modes in the assessment protocol is important. That is, sentence repetition task is a useful and economic method in providing a speech sample to establish whether certain targets can be obtained. Also it offers information on an individual's phonetic repertoire (Brøndsted, *et al.*, 1994; Sell *et al.*, 1994; Sell *et al*., 1999; Lohmander and Olsson, 2004; Henningsson *et al*., 2009). Including sentence repetition as an elicitation mode is also important as evaluating resonance tend to be more prominent in connected speech rather than single words (Sell *et al*., 1999). In addition, eliciting single words is also important in offering information about the individual's articulatory abilities in less challenging contexts (Howard, 1993).

The protocol can also be used as a clinical assessment tool by speech language therapists in Saudi Arabia. However, in the future, the protocol needs to be tested and evaluated more thoroughly in terms of its validity, reliability and efficacy. Obviously, important modifications were applied to the Arabic version of GOS.SP.ASS to account for and adapt to the structure of the language. In general, the structure of GOS.SP.ASS'98 is suitable for modification to be used as an assessment of tool for different languages. Furthermore, the list of single words and sentences that were used in the Saudi Arabian version of GOS.SP.ASS are applicable to other Arabic dialects, however with it needs some modifications especially in the use of vocabularies.

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Appendices

Appendix 1: Departmental ethics approval

The University Of Sheffield.

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Head of Department
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12th April 2011

Dear Nisreen

Title: Speech Characteristics of Saudi Children with repaired Cleft Palate

Thank you for your submission to the HCS Research Ethics Committee. The committee has reviewed your submission and supporting documents and grants you approval to commence the research.

We hope your project proceeds smoothly

Yours sincerely

Prof R Varley
Chair of HCS Ethics Committee

APPENDIX 2: EXAMPLES OF CONSENT FORMS AND INFORMATION SHEETS USED FOR PARTICIPANT RECRUITMENT

The University Of Sheffield.

Research Project Consent Form

Speech Characteristics of Saudi Children with repaired Cleft Palate

Dr. Sara Howard
Professor Bill Wells
Department of Human Communication Sciences
University of Sheffield

Miss. Nisreen Naser Al-Awaji
Department of Human Communication Sciences
University of Sheffield

Please initial the boxes below, as appropriate

1. I confirm that I have read and understood the information sheet for the project named above and that I have had the opportunity to ask questions about it. ☐

2. I understand that my child's participation is voluntary and that I am free to withdraw my consent at any time without giving a reason. ☐

3. I understand that the speech recordings and written information about my child will be given a code to keep my child anonymous and my child's name will not be disclosed. ☐

4. I understand that the video footage of my child will not be edited and my child's face will not be anonymous on the video. ☐

5. I give permission for my child to take part in the above research project. ☐

6. I give permission for the anonymised video and/or audio recordings collected for this study to be stored, securely and confidentially, for longer than the duration of the study. I understand that when the research team judges that no further analyses will be carried out on the recordings, they will be destroyed.

7. I give permission for video and/or audio recordings of my child's speech to be used for teaching purposes in the education of students in the Department of Human Communication Sciences, University of Sheffield, UK.

8. I give permission for video recordings and/or audio recordings of my child's
9. speech to be included in scientific presentations at conferences and meetings of other academics and professionals working in related area.

____________________	____________	________________
NAME OF PARTICIPANT *(or legal representative)*	DATE	SIGNATURE
Nisreen Naser Al-Awaji	____________	________________
CHIEF INVESTIGATOR	DATE	SIGNATURE

(To be signed and dated in the presence of the participant)

A copy of this form, once signed by all parties and dated, will be given to the parent, together with a project information sheet. A copy of the signed and dated form will be kept in the main project file, in a secure location, by the project team.

Research Project Information Sheet

Speech Characteristics of Saudi Children with repaired Cleft Palate

Miss Nisreen Naser Al-Awaji

Dr. Sara Howard
Professor. Bill Wells

Department of Human Communication Sciences
University of Sheffield

You have been given this information sheet because you are being asked to consider whether or not you wish your child to take part in this research project. You will not be asked for a decision at this point. You are given two weeks to think about it and make your decision. Please read the information carefully and feel free to discuss this with others if you wish. If you need further clarification or have any questions, you can ask the researcher for this project, Nisreen Naser Al-Awaji who will be able to answer any further queries you may have.

This sheet will explain what is involved in the project in more detail. If you decide you are happy for your child to take part you can contact the researcher (either by email or telephone) and then the researcher will meet you personally or give you a ring to discuss the project with you and arrange appointments to suit you.

Whether or not you decide to take part in the study will not affect you or your child in any way and your child does not have to take part. If you do decide to take part you are still free to withdraw from the study at any point without having to give a reason. If you withdraw from the study no record of your child's participation to that point will be kept by the researchers.

Thank you for reading this information sheet.

The Research Team

Nisreen Naser Al-Awaji, BSc, MSc, is a qualified Speech and Language Pathologist and a PhD student in the Department of Human Communication Sciences, The University of Sheffield, UK. Dr Sara Howard and Professor Bills Wells work in the Department of Human Communication Sciences, The University of Sheffield, UK lecturing, supervising and carrying out research into speech and communication impairments.

What are we hoping to find out?

The project aims to investigate how speech production is affected in Arabic-speaking children who have had an operation for a cleft palate. Studies on other languages have shown that cleft lip and/or palate often affect speech production, but there are currently few studies on cleft palate speech in Arabic. The aim of this project is therefore to describe the speech production of Arabic-speaking children who have had a cleft palate and also to compare their speech production with the speech of Arabic-speaking children of similar age who have not had a cleft palate.

We intend to do this by making audio and video recordings of the children's speech. We will then listen to the recordings and make detailed phonetic transcriptions of the speech (writing down how the children are producing sounds using a special symbol system). From this information we will investigate whether the speech production of the children with cleft palate is different from typical speech and look at the ways in which it differs. Understanding more about how cleft palate affects speech production in children who have had surgery may help speech pathologists to provide better treatments so that children with cleft can speak better.

Why has my child been asked to take part?

We have asked your child to participate because they:

- Have a repaired cleft lip and palate.
- Are aged between 4 and 7 years old.
- Are currently attending speech and language therapy for a speech difficulty related to their cleft palate.
- Do not have congenital problems.
- Do not have severe hearing impairment.

Does my child have to take part?

No. It will be your choice as to whether you would like your child to take part in the research project. It will not affect your child's allocation of speech and language therapy in any way. Your child will still see his/her normal speech and language pathologist.

If you do decide he/she can take part, you will be asked to sign a consent form. You can withdraw at any stage and at this point any recordings of your child's speech will be destroyed. This will not affect their speech and language therapy at all.

What will happen if my child decides to take part?

The researcher, Nisreen Naser Al-Awaji, will meet you personally or give you a ring to discuss the project with you and arrange appointments to suit you.

Then, you will bring your child to the hospital as usual for an appointment for speech therapy. We will make video and audio-recordings of your child saying some words and sentences for the purposes of the research project. The appointment should take about an hour.

What are the potential disadvantages and risks of taking part?

As recording your child's speech is a routine part of speech therapy, we don't see any specific risks or disadvantages to your child taking part in the study. We will need you to be available to come for one session at the hospital for the recording session with the date and time arranged with you to ensure this is convenient.

What are the potential advantages of taking part?

We cannot promise that your child will benefit from this study, although the information we find will be passed on to your child's speech and language therapist and we will send you a report of our findings. We hope the information we find may contribute to improving the treatment of individuals with cleft palate speech in the future. If you are interested to know about the results of the study we will send you a report of our findings.

Will my child be identified in any way through taking part in the project?

The researcher, Nisreen Al-Awaji, will keep copies of the speech recordings and video securely locked in her office. Only members of the research team (Nisreen Al-Awaji and her supervisors) will have access to the recordings.

Your child will be given an anonymous code for the duration of this project so they are not identifiable on any written material produced by the researcher or on computer (also password protected). You can have free access to listen to or watch the recordings should you wish.

The video will contain footage of your child saying some words and sentences and will not be edited to make your child's face anonymous. However, only the research team and yourselves will have access to the video. You will be specifically asked whether you consent to the video being shown for any additional reason such as a scientific presentation or for teaching others. You do not have to agree to this if you do wish your child to participate in this study. If you do agree you will be asked to view the video before it is used to check you are happy for us to use the footage. We will ask you to sign to say you consent the video to be used for any additional purpose at the time it is needed.

The recordings will be kept for the duration of this study (until 2013) and, if it becomes necessary, you will be asked to give your consent for longer term storage. You are free to refuse to give this extra consent. When the recordings are no longer being used for research purposes, they will be destroyed.

What will happen to the results of the project?

The results will form part of the researcher's PhD thesis and may be published in scientific journals or presented at research conferences. The results may also be presented to local groups and organisations supporting children with speech difficulties.

The research data collected on this project could possibly be used for future research, as part of scientific presentations, or for teaching or informing others about our findings. You will be specifically asked whether you wish the data to be used for other purposes. You will not have to agree to this and if you are happy for us to use the data in this way you will be asked to sign to say that you consent to the data being used for these additional purposes.

What will happen if I do not want my child to take part in the project, or if I change my mind about this at a later date?

You do not have to agree for your child to take part in the project and this will not affect your child's speech and language therapy in any way. You and your child are free to withdraw from the study at any point and you will not be asked to give a reason for this. If you withdraw, all copies of recordings of your child will be destroyed at that point. This will not affect your child's speech and language in any way. It is completely your choice.

What if there is a problem or I wish to make a complaint?

If you have any concerns feel free to discuss these with the researcher, Nisreen Naser Al-Awaji (+44 (0) 114 222 2413in UK) or her supervisors Dr. Sara Howard (+44 (0) 114 222 2448; email: s.howard@sheffield.ac.uk) or Professor Bill Wells (+44 (0) 114 222 2429; email: bill.wells@sheffield.ac.uk). . If you wish to discuss concerns with someone unrelated to the project you can contact Professor Shelagh Brumfitt, who is the Head of the Department of Human Communication Sciences, University of Sheffield, (+44 (0) 114 222 2406)If you are not satisfied your concerns have been dealt with satisfactorily by the people above, you can complain formally to the Registrar and Secretary of the University of Sheffield, Western Bank, Sheffield, S10 2TN. If you would like to make a complaint but do not wish to express it in English, you can write in Arabic, and send it to Dr Sara Howard, who will make arrangements for its translation.

Who has reviewed this project to ensure that it is of a suitable research standard and that it meets ethical requirements?

This project has been reviewed by the **Research Ethics Committee** of the Department of Human Communication Sciences, **University of Sheffield**

If you have any questions, please contact the researcher,

Nisreen Naser Al-Awaji
Department of Human Communication Sciences
University of Sheffield
31 Claremont Crescent
Sheffield
S10 2TA
Tel: (+44 (0) 114 222 2413 in (in UK)
Email: hcp09nna@sheffield.ac.uk

Thank you for reading this information sheet.

APPENDIX 3: SAUDI ARABIAN GOS.SP.ASS SPEECH PROFILE FOR CHILDREN WITH CLEFT PALATE AND/OR VELOPHARYNGEAL DYSFUNCTION

Arabic GOS.SP.ASS Speech Profile for Children with cleft palate and/or Velopharyngeal Dysfunction

Name	Date
Gender	Type of cleft
Age	MR number

I. Resonance

Hypernasality 0 -1-2-3 inconsistent consistent
Hyponasality Present Absent
Mixed resonance Present Absent
Cul de sac Present Absent

II. Nasal Airflow

Nasal emission Present Absent inconsistent Consistent inaudible inaudible
Nasal turbulence Present Absent inconsistent Consistent

III. Grimace

Present Absent inconsistent Consistent

VI. Mirror test

	Right	Left
pa pa		
pi pi		
ka ka		
ki ki		
ssss		

I. Consonant production

	Labial			Dental		Alveolar							Post-alveolar		Emphatics				Velar	Uvular			Pharyngeal		Glottal	
	m	b	f	ð	θ	n	l	t	d	s	z	r	ʃ	dʒ	sˤ	dˤ	tˤ	ðˤ	k	ʁ	χ	q	ħ	ʕ	h	ʔ
WI																										
WM																										
WF																										

Cleft Speech Characteristics

Active CSCs	***Passive CSCs***
Anterior CSCs Misarticulations involving the tongue tip/blade sounds: o Dentalisation o Interdental articulation o Linguolabial articulation Lateralisation and lateral articulation o Palatalisation and palatal articulation o Double articulation ***Posterior CSCs*** o Backing o Active nasal fricatives o Velopharyngeal fricative	o Nasalised/weak consonants o Absent pressure consonnas o Gliding of fricatives and/or affricates o Nasal realisation of plosives, fricatives and/or affricates

Developmental errors

Transcription

Summary of speech pattern

0 Normal consonants	0-1 No CTCs	1 Anterior oral CTCs	2 Posterior oral CTCs
3 Non-oral CTCs	4 Passive CTCs	5 Developmental errors	6 Others

Speech and language therapy

0 Unnecessary	1 Waiting list	2 Therapy ongoing	3 Regular review
4 Unavailable	5 No uptake		

Voice

0 normal 1 voice disorder

Visual appearance of speech

Oral examination

1.Nose	0 Unremarkable	1 Deviated septum	2 Obstructed	
2.Lips	0 Unremarkable	1 Restricted movement	2 Open mouth posture	
3.Occlusion	0 Class 1	1 Class 11	2 Class 111	
4.Dentition	0 Supernumerary	1 Deviated septum	2 Missing teeth	
5.Tongue	0 Unremarkable	1 Poor mobility	2 Abnormal posture	
6.Palatal Fistula	0 Absent	1 Present		
7.Fistula size	1 Minute <than 2mm 4 Large>8mm	2 Small between 2-5mm 5 Complete breakdown	3 Medium between 5-8mm	
8.Fistula location	1 Uvula 4 Hard palate-post alveolus 7 Hard palate and buccal sulcus	2 Soft palate 5 Buccal sulcus	3 Junction soft/hard palate 6 Other (describe)	
9.Palate mobility	0 Marked	1 Moderate	2 Slight	3 None
10.Soft palate	1 Bifid uvula	2 Notch	3 Blue/thin looking	
11.Nasopharynx	1 Tonsils 2 Apparently deep pharynx 3 Pharyngeal wall movement 4 Pharyngeal flap			

Aetiology

1 Suspected VPI
2 Confirmed VPI
3 Abnormal dentition
4 Malocclusion
5 Diagnosed hearing loss
6 Suspected hearing loss
7 Oral fistula
8 Cleft palate history
9 Intellectual deficit
10 Developmental
11 Environmental
12 Syndrome
13 Other

Areas requiring further assessment

Relevant information from parents

Management

Additional notes

______________________ ______________________

Speech and language therapist Signature

Saudi Arabian GOS.SP.ASS sentences and single words

Sound	Arabic sentence	Translation	Transcription
/m/	يحمل محمد القلم-	-Mohammed is holding a pen	-/jaħ.mɪlmaħam.madəlgalam/ -/jaħ.mɪlmaħam.madəlgaʟam/
/b/	باب البيت بني-	-The door's colour is brown	-/ba:bəlbajtbun.ni/ /ba:bəlbɛ:tbun.ni/
/f /	رفوف الفصل فاضية -	-The shelves of the class are empty	-/rufufəl.fasˤlfa:dˤɪjah/
/ ð/	منذر تلميذ ذكي -	-Munther is a smart student	-/mun.ðɪrtɪl.mi:ððaki: /
/n/	- نحـــــن نقـــــرأ القران	-We are reading the holy Quraan	-/naħ.nunaq.raʔəlqurʔa:n/
/l/	غسلت الفلفل والليمون	-I washed the pepper and the lemon	-/ʁasaltəlfil.filwal.lajmu:n/
/t/	اشتريت تفاح وبرتقال-	-I bought apple and orange	/ʔɪʃ.tarɛ:jttuf.fa:ħwabur.tuqa:l/
/s/	خمس سيارات اسعاف- غسلت سارة الملابس-	-Five ambulances -Sara washed the clothes	-/χamssaj.ja:ra:tʔɪs.ʕa:f/ -/ʁasalatsa:raəl.mala:bis/
/d/	دخل أحمد المدرسة-	Ahmed entered the school	/daχalʔaħmadəlmad.rasah/
/z/	زرعت جزر وموز-	I have planted carrot and banana	/zaraʕtdʒazarwamo:z /
/ʃ/	شجرة المشمش-	Apricot tree	/ʃadʒaratəl.mɪʃ.mɪʃ /
/dʒ/	جلس ماجد على الدرج-	Majid is sitting on the stairs	/dʒalasma:dʒɪdʕaladdaradʒ /
/k/	أكلت كريمة الكيك-	-I ate a chocolate cake	/ʔakal.tkɛrɛ:matəl.kɛ:k /
/h/	هدية مها جميلة-	-Maha's gift is beautiful	/hadɪj.jatmahadʒami:lah/
/ðˤ/	ظفر ظافر نظيف-	-Thafer's nails are clean	/ðˤɪfɪrðˤa:fɪrnaðˤi:f/
/sˤ/	مقص أصفر صغير-	- small yellow scissors	/ maqasˤʔasˤ.farsˤaʁi:r/

/dˤ/	ضـــفدع اخضـــر وبيضــــه ابيض-	-A green frog with a white egg	/dˤɪf.daʕʔaχ.dˤarbɛːdˤʊhʔab.jadˤ /
/tˤ/	طيارة مربوطة بالخيط-	-A kite tied with a string	/tˤaj.jaːrahmar.buːtˤahbɛl.χajtˤ /
/ʕ/	عين معن تلمع-	-Ma'an had a sparkle in his eyes	/ʕɛːnmaʕantɪl.maʕ/
/χ/	خلود تخلط الخوخ	-Kholoud is blending the peach	/χʊludtɪχ.lɪtˤəl.χoːχ/
/θ/	ثلاث كمثرات-	-Three pears	/θalæθkʊmɪθ.ræt/
/ħ/	حزام فرح احمر	-Farah has a red belt	/ħɪzaːmfarahʔaħ.mar/
/r/	رمى ناصر الكورة	-Rami threw the ball	/ramanaːsˤɪrəl.kuːrah/
/ʁ/	غسلت الشماغ في المغسلة	-I washed the shumaq in the sink	/ʁasaltəʃ.ʃʊmaːʁfɪlmaʁ.salah/
/q/ or /g/	قرد واقف على الطريق	-Monkey is standing in the road	/gɪrdwaːgɪfʕalatˤtˤariːg/ /qɪrdwaːqɪfʕalatˤ. tˤariːq/
/w/	فراولة واحدة	-One strawberry	/faraːw.lahwaːhɪdah/
/j/	يجلس الشرطي في سيارته	-The policeman is sitting in his car	/jadʒ.lɪsəʃ.ʃʊr.tˤifɪsaj.jaːratɪh/

Word Initial	Arabic Word	Translation	Transcription
1. /ʔ/	ارنب	Rabbit	/ ʔar.nab/
2. /b/	بيض	Egg	/bɛːdˤ/
3. /t /	تفاحة	Apple	/tʊf.faːħah/
4. / θ /	ثوب	Saudi uniform	/θalæθ/or/θoːb/
5. / dʒ /	جالس	Sitting	/dʒælɪs/
6. / ħ /	حلاوة/ حليب	Milk, Sweet	/ħalib/ ,/ħalæwah/
7. /χ /	خيار/ خروف	Sheep, Cucumber	/χaruːf/,/χɪjaːr/
8. / d /	دكتور	Doctor	/dʊk.toːrah//dʊk.tuːr ah/
9. /ð /	ذيل	Tail	/ðɛːl/
10. / z /	رجال	Man	/rɪ.dʒ.dʒaːl/
11. / r/	زرافة	Giraffe	/zaraːfah/
12. / s /	سيارة	Car	/saj.jaːrah/
13. / ʃ /	شاي	Tea	/ʃaːj//ʃaːhi/
14. / sˤ /	صرصور/ صابون	Soap, cockroach	/sˤaːbun//sˤar.sˤuːr/
15. / dˤ /	ضفدع	Frog	/dˤʊf.daʕ/
16. /tˤ /	طائرة	Airplane	/tˤaːʔɪrah//tˤaj.jaːrah/
17. /ðˤ /	ظهر	Back	/ðˤahar/
18. /ʕ /	عنب	Grape	/ʕɪnab/
19. / ʁ /	غسالة	Washing machine	/ʁas.saːlah/
20. / f /	فيل	Elephant	/fil/
21. /q /	قرد	Monkey	/qɪrd/
22. / k /	كتاب	Book	/kɪtaːb/
23. /l /	ليمون	Lemon	/laj.muːn/
24. / m /	مفتاح/ موز	Banana, Key	/moːz//mɪf.taːħ/
25. /n /	نظارة	Eyeglasses	/naðˤ.ðˤaːrah/
26. /h /	هدية	Gift	/hadɪj.jah/
27. /w /	وردة	Flower	/war.dah/
28. /j /	يد	Hand	/jad/

Word Medial	Arabic Word	Translation	Transcription
1. /ʔ/	شمعة	Candle	/ʃam.ʕah/
2. /b/	جبن	Cheese	/dʒʊbʊn/or/dʒʊb.n ah/
3. /t /	مفتاح	Key	/mɪf.taːħ/
4. / θ /	مثلث	Triangle	/mʊθal.laθ/
5. / dʒ /	رجال	Man	/rɪ.dʒaːl/
6. / ħ /	احمر	Red	/ʔaħ.mar/
7. /χ /	مخدة	Pillow	/mʊχad.dah/
8. / d /	مدرسة	School	/mad.rasah/
9. /ð /	اذن	Ear	/ʔʊðʊn/or/ʔɪðɪn/
10. / z /	جزر,ازرق	Blue, carrot	/ʔaz.raq /,/dʒ azar/
11. / r/	جرس	Bell	/dʒ aras /
12. / s /	أسنان	Teeth	/ʔas.naːn/
13. / ʃ /	فراشة	Butterfly	/faraːʃah/
14. / sˤ /	عصير	Juice	/ʕasˤiːr/
15. / dˤ /	اخضر	Green	/ʔaχ.dˤar/
16. /tˤ /	عطر,مطر	Rain ,Perfume	/matˤar/,/ʕɛtˤɪr/
17. /ðˤ /	نظارة	Eyeglasses	/naðˤ.ðˤaːrah/
18. /ʕ /	شمعة	Candle	/ʃam.ʕah/
19. / ʁ /	مغسلة	Sink	/maʁ.salah/
20. / f /	سلحفاة	Turtle	/sʊl.ħafah/
21. /q /	مقص	Scissor	/mɪqasˤ/
22. / k /	سكين	Knife	/sɪk.kiːn/
23. /l /	كلب	Dog	/kal.b/
24. / m /	شمعة	Candle	/ʃam.ʕah/
25. /n /	بنت	Girl	/bɪn.t/
26. /h /	ظهر	Back	/ðˤahar/
27. /w /	فراولة	Strawberry	/faraːw.lah/
28. /j /	سيارة	Car	/saj.jaːrah/

Word Final	Arabic Word	Translation	Transcription
1. /m/	خاتم	Ring	/χaːtam/
2. /b/	باب	Door	/baːb/
3. /f/	خروف	Sheep	/χaruːf/
4. / ð /	قنفذ	Hedgehog	/qʊn.fʊð/
5. / n /	ليمون	Lemon	/laj.muːn/
6. / l /	حبل	Rope	/ħabɪl/
7. /t /	بنت	Girl	/bɪnt/
8. / s /	جرس/شمس	Sun /Bell	/ʃam.s/,/dʒaras/
9. /d /	ولد	Boy	/walad/
10. / z /	موز	Banana	/moːz/
11. / ʃ /	ريش	Feather	/riʃ/
12. / dʒ /	دجاج/درج	Stair, Chicken	/daradʒ/ ,/dadʒædʒ/
13. / k /	كيك	Cake	/kɛːk/
14. / h /	هدية	Gift	/hadɪj.jah/
15. / ðˤ /	**….**	….	….
16. /sˤ /	مقص	Scissor	/mɪqasˤ/
17. /dˤ /	ابيض	White	/ʔab.jadˤ/
18. /tˤ /	خيط	Thread	/χɛːtˤ/
19. / ʕ /	ضفدع	Frog	/dˤɪf.daʕ/
20. /ʔ /	دواء	Medicine	/dawæʔ/
21. /χ /	مطبخ	Kitchen	/matˤ.baχ/
22. / θ /	مثلث	Triangle	/mʊθal.laθ/
23. /ħ /	مفتاح	Key	/mʊf.taːħ/
24. /r /	قطار	Train	/qɪtˤaːr/
25. /ʁ /	شماغ	Shumaq	/ʃʊmaːʁ/
26. /q /	صندوق	Box	/sˤʊn.duːq/
27. /w /	----	----	------
28. /j /	شرطي/ شاي	Policeman/tea	/ʃʊr.tˤij//or/ʃaːj/

APPENDIX 4: EXAMPLES OF CONSENT FORMS AND INFORMATION SHEETS USED FOR PARTICIPANT RECRUITMENT

The University Of Sheffield.

Speech Characteristics of Saudi Children with repaired Cleft Palate

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Department of Human Communication Sciences

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Miss. Nisreen Naser Al-Awaji

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Guidelines for Transcription Exercise

You have been given this training material because you have agreed to carry out some phonetic transcription to enable measurement of transcription reliability in this research project. (For further information on the project as a whole, please refer to the Information Sheet which you have also been given). You have two weeks to read and go through the training material carefully and then a set of exercises will be provided to enable you to apply your transcription skills for cleft palate speech. After this phase, a set of audios and videos containing words and sentences produced by children with speech associated with cleft palate will be provided, so you can start making your transcriptions.

The training material includes the Training Video from the GOS.SP.ASS (Great Ormond Street Speech Assessment) and a PowerPoint that includes videos of children with cleft speech errors and other developmental speech errors. The purposes of providing videos is to provide ear-training for you about the speech characteristics related to cleft palate and therefore to facilitate making transcriptions.

Structure of the training material:

The material summarises a description of cleft palate speech characteristics including resonance, nasal emission, nasal turbulence, and grimace and other cleft palate characteristics, including dentalisation, lateralisation, palatalisation, double articulation, backing, and glottal articulation.

What are we hoping to find out?

The project aims to investigate how speech production is affected in Arabic-speaking children who have had an operation for a cleft palate. Studies on other languages have shown that cleft lip and/or palate often affects, speech production, but there are currently few studies on cleft palate speech in Arabic. The aim of this project is therefore to describe the speech production of Arabic-speaking children who have had a cleft palate and also to compare their speech production with the speech of Arabic-speaking children of similar age who have not had a cleft palate.

We have done this by making audio and video recordings of the children’s speech. We have then listened to the recordings and made detailed phonetic transcriptions of the speech. From this information we will investigate whether the speech production of the children with cleft palate is different from typical speech and look at the ways in which it differs. Understanding more about how cleft palate affects speech production in children who have had surgery may help speech pathologists to provide better assessment and further management.

Then, why do we want you to do phonetic transcription?

The aim of asking you to do phonetic transcription is to facilitate measurement of the reliability of the phonetic transcriptions made in this study.

Why I have specifically been asked to take part?

You have been asked to take part because:

- You are a qualified speech language pathologist, familiar with atypical speech production.
- Your first language is Arabic.
- You have experience of carrying out phonetic transcription for clinical purposes, using the IPA and ExtIPA.

What are the required tasks?

1. Training materials will be provided along with this protocol. The training material involves GOS.SP.ASS Training Video and a PowerPoint that include videos for children with cleft palate who participated in the project who have presented with cleft speech errors and other developmental speech errors. You are asked to view the GOS.SP.ASS Training video and the PowerPoint videos of children producing single words and sentences. These will demonstrate each parameter of nasal resonance, nasal emission, nasal turbulence, nasal grimace, and all cleft palate speech characteristics along with additional features which were found in this project and the symbols used to transcribe them.
2. You will be given two weeks to use the materials to learn to identify and transcribe the cleft palate speech features.
3. A transcription task will then be given in order to allow a simple self-assessment.
4. You will then be ready to do the actual reliability transcription.

Transcription tools:

- The International Phonetic Alphabet symbols (IPA).
- ExtIPA symbols for disordered speech (ExtIPA).
- VoQS: Voice Quality Symbols.
- Cleft speech diagrams.
- Headphones: please use headphones for the transcription exercise. This is important to match the conditions under which the first transcribe listened to the data.

List of instructions:

1. **How many times do I need to listen to the target utterance?**

- Shriberg *et al*.(1984)three times to reduce too much sensory exposure which can lead to auditory illusions
- Analytical listening (Ashbey *et al*., 1996): listen to a certain phonetic feature many times.

2. **What can I do if I am not sure how to transcribe a bit of the data?**

   You can simply use the nearest accurate symbol to transcribe the target word.

3. **Where can I list my answers?**

   An online questionnaire will be given that involve the questions along with the target utterances and you need to fill in the missing part with your transcription.

4. **Will my name be identified in any way through taking part in the project?**

   The researcher (Nisreen Naser Al-Awaji and her supervisors) will only have the access to you transcriptions. You will be given an anonymous code so that you are not identifiable on any written material produced by the researcher or on computer (also password protected).

If you need further clarification or have any questions, you can ask the researcher for this project, Nisreen Al-Awaji who will be able to answer any further queries you may have.

APPENDIX 5: LISTS OF ACCEPTABLE VARIANTS

/dˤ/	[dˤ , d or ðˤ]
/q/	[q,k,g,ɢ,ʔ]
ʔ	[ʔ or ø] (word-medial)
ðˤ	[ðˤ,dˤ]
sˤ	[sˤ ,zˤ](word-final in some words)
θ	[θ,t]
ð	[ð,d]
dʒ	[dʒ , ʒ]
j	[j,ʔ] (word-initial in some words)

- (Amayreh and Dyson, 1998; Dyson and Amayreh ,2000).

Appendix 6: Percentage of segmental accuracy for all children with cleft palate in word-Initial position

Consonants / Child Int.	Plosives (%)								Fricatives (%)													Affr[a]	Nasals(%)		Liquid/Glide (%)			
	ˤb(5)	t(1)	d(5)	k(3)	q(4)	tˤ(1)	dˤ(2)	ʔ (4)	f(3)	θ(1)	ð(1)	s(4)	z(1)	ʃ(6)	sˤ(3)	ðˤ(2)	χ(4)	ɣ(1)	ħ(3)	ʕ(3)	h(2)	dʒ(5)	m(13)	n(2)	r(3)	w(2)	l(2)	j(1)
AG	100	100	100	100	100	100	0	75	100	100	100	75	100	16.6	0	100	100	100	66.6	100	100	100	100	100	100	100	100	100
AM	100	100	100	100	50	100	0	100	100	100	100	0	0	16.6	0	100	100	100	66.6	100	100	0	85	100	100	100	100	0
Da	100	0	80	100	75	0	50	100	100	0	100	75	100	83.3	66.6	0	100	100	100	100	100	0	92	100	100	100	100	100
Di	60	100	100	100	100	100	100	100	100	100	100	50	0	0	0	100	75	100	100	100	100	0	100	100	100	100	100	100
Gh	80	100	100	100	100	0	100	100	100	100	100	25	0	33.3	0	100	75	100	100	100	100	100	100	100	100	100	100	100
Jo	80	100	80	100	100	100	0	100	100	100	100	0	100	100	66.6	100	100	100	100	100	100	20	92	100	100	100	100	100
Ju	100	100	80	100	100	100	100	100	100	100	100	25	100	33.3	0	100	100	100	66.6	100	100	40	100	100	0	100	100	100
Ma	100	0	80	66.6	100	100	100	100	100	100	100	0	0	100	0	100	100	0	66.6	100	100	40	100	50	100	100	0	100
Me	60	0	100	0	25	0	100	100	33.3	100	100	0	0	0	0	100	75	100	100	100	100	80	100	100	100	100	100	100
Mis	100	100	80	100	75	100	0	100	100	100	100	75	100	100	66.6	100	75	100	100	100	100	100	92	100	100	100	100	100
Moh	100	0	100	100	100	100	100	100	100	100	100	0	0	100	0	100	100	100	100	100	100	100	100	100	100	100	100	100
Mon	40	0	100	66.6	0	0	0	100	100	0	100	0	0	33	33	100	100	100	100	100	100	80	85	100	100	100	100	0
Mu	100	100	20	66.6	100	100	0	100	33	100	0	0	0	17	0	0	75	100	100	100	100	40	100	100	100	100	100	0
Nah	100	100	100	100	100	100	100	100	100	100	100	0	0	0	0	100	100	100	33	100	100	80	100	100	100	100	100	100
Nas	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	100	0	100	100	100	0	85	100	0	100	0	100
Os	100	100	80	100	100	100	0	100	100	100	0	100	0	0	33	100	100	100	100	100	100	0	77	100	100	100	100	100
Re	100	100	100	100	75	100	100	100	100	0	100	50	100	100	0	100	100	100	100	100	100	80	100	100	100	100	50	100
Sa	100	100	60	33.3	100	0	50	100	100	100	0	0	0	0	0	0	75	100	67	100	100	0	100	100	67	100	100	0
Sau	40	0	20	0	0	0	0	100	0	100	0	0	0	0	0	50	0	0	100	100	100	0	62	100	0	100	50	100
Sh	20	0	60	100	100	100	0	100	0	0	0	0	0	0	0	50	75	100	100	100	100	0	100	100	67	100	100	100
Ta	100	0	100	0	0	0	0	100	100	0	100	100	100	0	0	0	0	0	33	33	100	0	92	100	0	100	100	100
Mean[b]	**80**	**57**	**78**	**73**	**71**	**62**	**43**	**99**	**79**	**71**	**71**	**27**	**33**	**35**	**13**	**71**	**82**	**81**	**86**	**97**	**100**	**41**	**93**	**98**	**78**	**100**	**86**	**81**

a. Affricate (%), b. Mean segmental accuracy for all children (*n*=21) in the word-initial position

Percentage of segmental accuracy for all children with cleft palate in word-medial position

Consonants / Child Int.	Plosives (%)								Fricatives (%)													Affr[a]	Nasals(%)		Liquid/Glide(%)			
	ᶜb(4)	t(5)	d(6)	k(2)	q(2)	tˤ(5	dˤ(1)	ʔ (1)	f(9)	θ(2)	ð(1)	s(4)	z(1)	ʃ(1)	sˤ(2)	ðˤ(2)	χ(2)	ɣ(1)	ħ(2)	ʕ(2)	h(2)	dʒ(3)	m(7)	n(7)	r(19)	w(2)	l(10)	j(5)
AG	100	100	100	100	100	100	100	100	100	50	100	100	0	0	50	100	50	100	100	100	100	100	100	100	73.7	100	100	100
AM	100	100	100	100	50	100	100	100	88.8	100	100	25	0	0	0	100	100	0	100	100	100	33.3	100	100	100	100	100	100
Da	100	100	83.3	83.3	50	100	0	100	100	50	100	75	0	100	50	100	100	100	100	100	100	0	100	100	89.5	100	100	100
Di	100	100	100	100	100	100	100	100	66.6	100	100	75	0	0	0	100	100	100	100	100	100	0	100	100	100	100	100	100
Gh	100	100	100	100	100	100	100	100	100	100	100	0	0	0	0	100	100	0	100	100	100	66.6	100	100	100	100	100	100
Jo	100	100	83.3	83.3	50	100	100	100	100	100	100	50	0	100	50	100	100	100	100	100	100	100	100	71.4	100	100	100	100
Ju	100	100	83.3	83.3	50	100	100	100	100	100	100	100	100	0	0	100	100	0	100	100	100	100	100	100	100	100	100	100
Ma	100	80	100	100	0	100	100	100	77.7	100	100	0	0	100	0	100	100	100	100	100	100	100	100	71.4	89.5	100	80	100
Me	75	20	83.3	83.3	100	100	100	100	55.5	100	100	0	0	0	0	100	50	0	100	100	100	33.3	100	100	100	100	100	100
Mis	100	100	100	100	100	100	100	100	100	100	100	100	100	0	50	100	50	100	100	100	100	100	100	100	57.9	100	100	100
Moh	100	100	100	100	100	100	100	100	88.8	100	100	50	100	100	0	100	50	100	100	100	100	100	100	85.7	84.2	100	100	100
Mon	25	20	66.6	66.6	0	100	0	100	44.4	100	0	50	100	100	50	100	50	0	100	100	100	100	100	100	78.9	100	90	100
Mu	100	80	66.6	66.6	100	100	100	100	88.8	0	100	0	0	0	0	100	100	0	100	100	100	33.3	100	71.4	57.9	100	100	100
Nah	100	100	100	100	100	100	0	100	100	100	100	0	0	0	0	100	100	0	100	100	100	100	71.4	100	100	100	100	100
Nas	0	0	0	0	100	100	0	100	0	0	0	0	0	0	0	50	100	100	100	100	100	0	100	100	5.26	100	100	100
Os	100	60	100	100	100	100	0	100	77.7	100	100	100	100	0	0	50	100	100	100	100	100	0	100	100	73.7	100	100	100
Re	100	100	100	100	50	100	100	100	100	100	100	100	100	100	50	100	100	100	100	100	100	100	100	100	94.7	100	100	100
Sa	100	40	83.3	83.3	50	100	100	100	77.7	100	100	25	0	0	0	100	100	100	100	100	100	66.6	100	100	52.6	100	100	100
Sau	25	0	0	0	0	0	100	100	0	0	0	0	0	0	0	100	0	0	100	100	100	0	85.7	100	0	100	20	100
Sh	25	20	50	50	50	100	0	100	44.4	0	100	0	0	0	0	0	100	0	100	100	100	0	100	85.7	73.7	100	100	100
Ta	100	60	100	100	0	100	0	100	88.8	100	100	25	100	0	0	0	100	0	100	100	100	0	100	100	5.26	100	100	100
Mean[b]	**83**	**70**	**81**	**64**	**95**	**52**	**67**	**100**	**76**	**76**	**86**	**42**	**33**	**29**	**14**	**86**	**83**	**52**	**100**	**100**	**100**	**54**	**98**	**95**	**73**	**100**	**95**	**100**

a.Affricate (%), b. Mean segmental accuracy for all children (*n*=21) in the word-medial position

Percentage of segmental accuracy for all children with cleft palate in word-final position

Children / Consonants	Plosives (%)								Fricatives (%)													Affr[a]	Nasals(%)		Liquid/Glide (%)			
	^{c}b(7)	t(2)	d(3)	k(1)	q(1)	tˤ(1)	dˤ(2)	ʔ (1)	f(2)	θ(2)	ð(1)	s(4)	z(1)	ʃ(1)	sˤ(2)	ðˤ	χ(1)	ɣ(1)	ħ(3)	ʕ(2)	h(18)	dʒ(2)	m(1)	n(6)	r(10)	w	l(4)	j(1)
AG	100	100	100	0	100	0	100	100	100	100	100	25	100	0	0		100	0	100	100	100	0	100	100	60		100	0
AM	57	100	100	100	0	100	0	100	0	50	0	0	0	0	0		100	0	100	100	89	0	100	33	60		75	0
Da	43	0	67	100	100	0	100	100	100	100	0	25	0	100	0		100	100	67	100	94	0	0	100	80		100	0
Di	100	100	100	100	100	100	100	0	100	100	100	100	100	0	100		100	0	100	100	100	0	100	100	100		100	0
Gh	14	0	67	100	100	0	50	100	0	100	100	0	0	0	0		100	0	100	100	100	50	0	100	80		100	0
Jo	43	50	33	100	100	100	100	0	100	100	100	50	0	100	0		100	0	100	100	100	50	0	67	100		100	0
Ju	100	100	67	100	100	100	100	100	100	100	100	50	0	100	100		100	100	100	100	100	50	0	100	60		50	0
Ma	86	0	33	100	0	100	100	0	100	50	100	0	0	0	0		100	100	100	50	100	0	100	83	60		100	0
Me	86	0	67	0	0	100	50	0	0	100	0	0	0	0	0		0	0	100	100	100	50	0	50	80		75	100
Mis	71	100	100	100	0	100	100	0	100	100	100	75	100	100	0		0	100	100	100	100	100	100	83	50		100	0
Moh	71	100	67	100	100	100	100	0	100	0	100	0	0	100	0		100	100	100	100	100	100	100	100	100		100	0
Mon	86	100	33	100	0	0	50	100	50	0	0	0	0	0	50		100	0	100	100	100	0	100	100	60		100	0
Mu	100	0	100	0	100	100	100	0	100	100	100	25	0	0	0		100	100	100	0	100	0	0	67	20		100	0
Nah	100	100	100	100	100	100	100	0	100	50	0	0	0	0	0		0	0	100	100	100	100	0	100	100		100	0
Nas	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0		100	0	100	100	94	0	0	50	0		50	0
Os	14	100	100	100	0	100	0	0	100	0	100	75	100	0	0		100	0	67	100	94	0	100	100	70		75	0
Re	0	100	67	100	100	100	100	0	100	100	100	50	100	100	0		100	100	100	100	94	50	100	100	100		75	0
Sa	0	0	33	100	100	0	0	0	50	50	0	0	0	0	0		100	0	67	100	100	0	0	67	20		75	0
Sau	29	0	0	0	0	0	50	0	0	0	0	0	0	0	0		0	0	100	100	100	0	100	83	0		50	0
Sh	14	0	67	100	100	0	50	0	0	50	0	0	0	0	0		0	100	100	100	72	0	0	33	30		25	0
Ta	71	100	100	0	100	0	0	0	100	0	100	100	100	0	0		100	0	100	100	94	0	100	100	0		100	0
Mean[b]	**56**	**55**	**67**	**71**	**62**	**57**	**64**	**29**	**69**	**60**	**57**	**27**	**29**	**29**	**12**		**76**	**38**	**95**	**93**	**97**	**26**	**52**	**82**	**59**		**83**	**5**

a.Affricate (%), b. Mean segmental accuracy for all children (*n*=21) in the word-final position

Appendix 7:

Nasreen's Feature Contrasts

	word-initial	word-medial	word-final
Nasal -Plosive m n- b t d k q tˤdˤ	m n - m ? ? ? ? ? ?	m n-m ? ? ? ? ? ?	m̥ n-m (t)(d)? ? (tˤ)?
Stop-Fricative b t d k q tˤdˤ-θ ð s z ʃ χ ʁ ðˤ ʕ h sˤ	m? ? ? ? ? ? - ? ? ? ? ? ? x ʕ	m? ? ? ? ? ?-? ? (tʰ,?) ? ? ? ʕħ ʕ	m̥? ? ? ? (tˤ) ?-h d̦ h? h x x ʕ h ?
Stop-Affricate b t d k q tˤdˤ-dʒ	m? ? ? ? ? ?-?	m? (tʰ,?) ? ? ? ?-?	h d̦ h? h x x ʕ h ?-?
Fricative-Affricate θ ð s z ʃ χ ʁ ðˤ ʕ h sˤ-dʒ	? ? ? ? ? ? x ʕ-?	? ? ? ? ? ? ħ ʕ-?	m̥? ? ? ? (tˤ) ?-?
Stop-Approximant b t d k q tˤdˤ-j l	m? ? ? ? ? ?-j n	m? ? ? ? ? ?-j l	m̥? ? ? ? (tˤ) ?-i l
Fricative-Approximant θ ð s z ʃ χ ʁ ðˤ ʕ h sˤ-j l	? ? ? ? ? ? x ʕ-j n	? ? ? ? ? ? ħ ʕ-j l	h d̦ h? h x x ʕ h ?-i l
Labial-Lingual b m f-θ ð t d n r s z ʃ l	m m ?-? ? ? ? n(ʋ, ?w)?-? ?n	m m ?-? ? ? ? n w?- ? ?l	m m̥ h-? d̦ (t)(d)n ʋ h ? l
Alveolar-Dental t d n r s z l- θ ð	? ?(ʋ, ?w)?? n-? ?	? ? n w ? ? l-? ?	(t)(d)n ʋ h? l-? d̦
Alveolar-Postalveolar t d n r s z l-ʃ	? ?(ʋ,?w)?? n-?	? ? n w?? l-?	(t)(d)n ʋ h? l-?
Alveolar-Velar (stops) t d -k	? ?-?	? ? -?	(t)(d)-?
Voiced-Voiceless ð d z dˤðˤ- θ t s ʃ tˤ sˤ	? ? ? ? ? ?-? ? ? ? ? ? ?	? ? ? ? ? ?-? ? ? ? ? ? ?	d̦ (d)? ? ?- ?(t)hh(tˤ)?
Emphatic-Non emphatic tˤðˤ dˤ sˤ-t ð d s	? ? ? ?-? ? ? ?	? ? ? ?-? ? ? ?	(tˤ)(ðˤ*)? ?-(t) d (d)h
Uvular-Pharyngeal (fric.) χ ʁ- ħ ʕ	xʕ - ħʕ	xʕ - ħʕ	x x-ħ ʕ

Saud's Feature Contrasts

	Word-initial	Word-medial	Word-final
Nasal -Plosive m n- b t d k q tˤdˤ	m n- m w̼ n n n̼ ð n̼	m nʰ- m n d n̼ n̼ n̼ dˤ	mʰ n - b̥ (t) ʰ(d) l ʰ ʔ n̼ d̥ˤ
Stop-Fricative b t d k q tˤdˤ- f θ ð s z ʃ χ ʁ ðˤ ʕ h sˤ	m w̼ n n n̼ ð n̼- n̼ θ ʔ θ ʔ n ħ ʕ ðˤʕ n̼	m n d n̼ n̼ n̼ dˤ- n̼ n̼ n̼ n d̥ˤ n ħ ʕ d̥ˤʕ d^{n}	b̥ (t) ʰ(d) l ʰ ʔ n̼ d̥ˤ -(f) n̼ n̼ (s) ʰ nʔʰ l ħ ʕ (-) ʕ h d̥ˤ
Stop-Affricate b t d k q tˤ dˤ-dʒ	m w̼ n n n̼ ð n̼- n̼	m n d n̼ n̼ n̼ dˤ- n̼	b̥ (t) ʰ(d) l ʰ ʔ n̼ d̥ˤ- {n̼ , l}
Fricative-Affricate **f** θð s zʃχʁðˤʕh sˤ-dʒ	n̼ θ ʔ θ ʔ n ħ ʕ ðˤʕ n̼- n̼	n̼ n̼ n̼ n d̥ˤ n ħ ʕ d̥ˤʕ d^{n}- n̼	(f) n̼ n̼ (s) ʰ nʔʰ l ħ ʕ (-) ʕ h d̥ˤ -{n̼ , l}
Stop-Approximant b t d k q tˤdˤ-j l	m w̼ n n n̼ ð n̼ - j n̼	m n d n̼ n̼ n̼ dˤ -j (l)	b̥ (t) ʰ(d) l ʰ ʔ n̼ d̥ˤ- i l
Fricative-Approximant f θ ð s z ʃ χ ʁ ðˤ ʕh sˤ-j l	n̼ θ ʔ θ ʔ n ħ ʕ ðˤʕ n̼ -j n̼	n̼ n̼ n̼ n d̥ˤ n ħ ʕ d̥ˤʕ d^{n} -j (l)	(f) n̼ n̼ (s) ʰ nʔʰ l ħ ʕ (-) ʕ h d̥ˤ -i l
Labial-Lingual b m f - θ ð t d n r s z ʃ l	m m n̼ - θ ʔ w̼ n n w θ ʔ n n̼	m m n̼- n̼ n̼ n d nʰ(r) n d̥ˤ n (l)	b̥ mʰ (f)- n̼ n̼ (t) ʰ (d) n(r̰) (s) ʰ nʔʰ l l
Alveolar-Dental t d n r s z l- θ ð	w̼ n n w θ ʔ n̼ -θ ʔ	n d nʰ (r) n d̥ˤ (l)- n̼ n̼	(t) ʰ (d) n (r̰)(s) ʰ nʔʰ l - n̼ n̼
Alveolar-Postalveolar t d n r s z l-ʃ	w̼ n n w θ ʔ n̼ - n	n d nʰ (r) n d̥ˤ (l)- n	(t) ʰ (d) n (r̰)(s) ʰ nʔʰ l- l
Alveolar-Velar (stops) t d -k	w̼ n - n	n d - n̼	(t) ʰ (d) - l ʰ
Voiced-Voiceless ð d z dˤ ðˤ- θ t s ʃ tˤ sˤ	ʔ n ʔ n̼ ðˤ- θ w̼ θ n ð n̼	n̼ d d̥ˤdˤd̥ˤ- n̼ n n n n̼ d^{n}	n̼ (d) nʔʰ d̥ˤ (-)- n̼ (t) ʰ (s) ʰ l n̼ d̥ˤ
Emphatic-Non emphatic tˤ ðˤ dˤ sˤ-t ð d s	ð ðˤ n̼ n̼ - w̼ ʔ n θ	n̼ d̥ˤdˤ d^{n} - n n̼ d n	n̼ (-) d̥ˤ d̥ˤ -(t) ʰ n̼ (d) (s) ʰ
Uvular-Pharyngeal (fric.) χ ʁ- ħ ʕ	ħ ʕ -ħ ʕ	ħ ʕ -ħ ʕ	ħ ʕ -ħ ʕ

Saad's Feature Contrasts

	word-initial	word-medial	word-final
Nasal -Plosive m n- b t d k q tˤdˤ	m n- b t̚ d̪ kʰ g t͡q d	m ŋ - b̥ t d k g [dˤ, tˤ] ðˤ	m n - p' h (d) k̚ ʰ g̚ ʔ ðˤ
Stop-Fricative b t d k q tˤdˤ-θ ð s zʃχʁðˤʕh sˤ	b t̺ d̪ kʰ g t͡q d - θ d̪ θ ð ɬ χ ʁ dˤ ʕ h θ	b̥ t d k g [dˤ, tˤ] ðˤ - θ d ɬ⊏ ð ç x ʁ dˤ ʕ h ɬ⊏	p' h (d) k̥ʰ g̥ ʔ ðˤ - θ s ɬ⊏ ʔɬ⊏ ɬ χ ʁ (--) ʕ h θ
Stop-Affricate b t d k q tˤdˤ-dʒ	b t̚ d̪ kʰ g t͡q d - d͡g	b̥ t d k g [dˤ, tˤ] ðˤ -dʒ	p' h (d) k̚ ʰg̚ ʔ ðˤ - gʰ
Fricative-Affricate θð s zʃχʁðˤʕh sˤ-dʒ	θ d̪ θ ð ɬ χ ʁ dˤʕ h θ - d͡g	θ d ɬ⊏ ð ç x ʁ dˤ ʕ h ɬ⊏ -dʒ	θ s ɬ⊏ ʔɬ⊏ ɬ χ ʁ (--) ʕ h θ -gʰ
Stop-Approximant b t d k q tˤdˤ-j l	b t̺ d̪ kʰ g t͡q d -j l̪	b̥ t d k g [dˤ, tˤ] ðˤ - j l	p' h (d) k̚ ʰg̚ ʔ ðˤ - i l
Fricative-Approximant θ ð s zʃχʁðˤʕh sˤ-j l	θ d̪ θ ð ɬ χ ʁ dˤʕ h θ -j l̪	θ d ɬ⊏ ð ç x ʁ dˤ ʕ h ɬ⊏ -j l	θ s ɬ⊏ ʔɬ⊏ ɬ χ ʁ (--) ʕ h θ -i l
Labial-Lingual b m f-θ ð t d n r s z ʃ l	b m f - θ d̪ t̚ d̪ n r θ ð ɬ l̪	b̥ m f - θ d t d ŋ ɾʷ ɬ⊏ ð ç l	p' m (f) - θ s h (d)
Alveolar-Dental t d n r s z l- θ ð	t̚ d̪ n r θ ð l̪ - θ d̪	t d ŋ ɾʷ ɬ⊏ ð l -θ d	h (d) n (r) ɬ⊏ ʔɬ⊏ l̚ ʰ - θ s
Alveolar-Postalveolar t d n r s z l-ʃ	t̺ d̪ n r θ ð l̪ - ɬ	t d ŋ ɾʷ ɬ⊏ ð l - ç	h (d) n (r) ɬ⊏ ʔɬ⊏ l̚ ʰ - ɬ
Alveolar-Velar (stops) t d -k	t̚ d̪ - kʰ	t d - k	h (d) -k̚ ʰ
Voiced-Voiceless ð d z dˤðˤ- θt s ʃ tˤ sˤ	d̪ d̪ ð d dˤ - θ t̺ θ ɬ t͡q θ	d d ððˤdˤ -θ t ɬ⊏ ç [dˤ, tˤ] ɬ⊏	s (d) ʔɬ⊏ ðˤ (…) - θ h ɬ⊏ ɬ ʔ θ
Emphatic-Non emphatic tˤðˤ dˤ sˤ-t ð d s	t͡q dˤ d θ -t̚ d̪ d̪ θ	[dˤ, tˤ] dˤɬ⊏ - t d d ɬ⊏	ʔ (…) ðˤ θ - h s (d) ɬ⊏
Uvular-Pharyngeal (fric.) χ ʁ- ħ ʕ	χ ʁ -ħ ʕ	x ʁ-ħ ʕ	χ ʁ -ħʕ

Shoog's Feature Contrasts

	word-initial	word-medial	word-final
Nasal -Plosive m n- b t d k q tˤdˤ	m n – b ñ̥ ŋ k q tˤ ŋ	m ŋ- b̥ t d̥ k g q ð̥ˤ	(m) n- b̥ (t) d̥ k q (tˤ) q
Stop-Fricative b t d k q tˤdˤ- f θ ð s zʃχʁðˤʕh sˤ	b ñ̥ ŋ k q tˤ ŋ - ñ̥ ñ̥ ŋg ñ̥ ñ̥ ñ̥ [x̥ ,ñg] ʁ ŋ ʕ h [θ̃, ñ̥]	b̥ t d̥ k g q ð̥ˤ - f (θ) ð ñ̥ ñ̥ ʃ̃ x ʁ̃ ð̥̃ ʕ h θ̃	b̥ (t) d̥ k q (tˤ) q - (f) θ̃ g [θ̃,ñ̥] ñ̥ θ̃ x̥ ʁ̥ ( ) ʕ h ñ̥
Stop-Affricate b t d k q tˤdˤ- dʒ	b ñ̥ ŋ k q tˤ ŋ -ñ̥	b̥ t d̥ k g q ð̥ˤ - đ̃.g	b̥ (t) d̥ k q (tˤ) q - [d̥ñ̥ ,g͡ʔʰ]
Fricative-Affricate f θð s zʃχʁðˤʕh sˤ-dʒ	ñ̥ ñ̥ ŋg ñ̥ ñ̥ ñ̥ [x̥ ,ñg] ʁ ŋ ʕ h [θ̃, ñ̥] - ñ̥	f (θ) ð ñ̥ ñ̥ ʃ̃ x ʁ̃ ð̥̃ ʕ h θ̃ - đ̃.g	(f) θ̃ g [θ̃,ñ̥] ñ̥ θ̃ x̥ ʁ̥ ( ) ʕ h ñ̥ -[d̥ñ̥ ,g͡ʔʰ]
Stop-Approximant b t d k q tˤdˤ-j l	b ñ̥ ŋ k q tˤ ŋ -j l	b̥ t d̥ k g q ð̥ˤ - j l	b̥ (t) d̥ k q (tˤ) q- i ʔ
Fricative-Approximant f θð s zʃχʁðˤʕh sˤ-j l	ñ̥ ñ̥ ŋg ñ̥ ñ̥ ñ̥ [x̥ ,ñg] ʁ ŋ ʕ h [θ̃, ñ̥]-j l	f (θ) ð ñ̥ ñ̥ ʃ̃ x ʁ̃ ð̥̃ ʕ h θ̃ -j l	(f) θ̃ g [θ̃,ñ̥] ñ̥ θ̃ x̥ ʁ̥ ( ) ʕ h ñ̥ -i ʔ
Labial-Lingual b m f - θ ð t d n r s z ʃ l	b m ñ̥ - ñ̥ ŋg ñ̥ ŋ n ɾ ñ̥ ñ̥ ñ̥ ñ̥	b̥ m f - (θ) ð t d̥ ŋ r ñ̥ ð̃ ʃ̃ l	b̥ (m) (f) - θ̃ g (t) d̥ n (r) [θ̃,ñ̥]ñ̥ θ̃ ʔ
Alveolar-Dental t d n r s z l- θ ð	ñ̥ ŋ n ɾ ñ̥ ñ̥ l - ñ̥ ŋg	t d̥ ŋ r ñ̥ ð̃ l - (θ) ð	(t) d̥ n (r) [θ̃,ñ̥]ñ̥ ʔ -θ̃ g
Alveolar-Postalveolar t d n r s z l-ʃ	ñ̥ ŋ n ɾ ñ̥ ñ̥ l - ñ̥	t d̥ ŋ r ñ̥ ð̃ l - ʃ̃	(t) d̥ n (r) [θ̃,ñ̥]ñ̥ ʔ - θ̃
Alveolar-Velar (stops) t d -k	ñ̥ ŋ n ɾ ñ̥ ñ̥ l - k	t d̥ ŋ r ñ̥ ð̃ l- k	(t) d̥ n (r) [θ̃,ñ̥]ñ̥ ʔ
Voiced-Voiceless ð d z dˤðˤ- θ t s ʃ tˤ sˤ	ŋg ŋ ñ̥ ŋ ŋ - ñ̥ ñ̥ ñ̥ ñ̥ tˤ [θ̃,ñ̥]	ð d̥ ð̃ ð̥ˤ ð̥̃ - (θ) t ñ̥ ʃ̃ q θ̃	g d̥ ñ̥ **q** ( )-θ̃ (t) [θ̃,ñ̥]θ (tˤ) ñ̥
Emphatic-Non emphatic tˤðˤ dˤ sˤ-t ð d s	tˤ ŋ ŋ [θ̃,ñ̥] - ñ̥ ŋg ŋ ñ̥- ñ̥ ŋ ñ̥	q ð̥̃ ð̥ˤ θ̃ - t ð d̥ ñ̥	(tˤ) ( ) q ñ̥ - (t) g d̥ [θ̃,ñ̥]
Uvular-Pharyngeal (fric.) χ ʁ- ħ ʕ	[x̥ ,ñg] ʁ -ħ ʕ	x ʁ̃ - ħ ʕ	x̥ ʁ̥ - ħ ʕ